This document is guaranteed to be current only to issue date.

Some Mars Global Surveyor documents that relate to flight operations are under revision to accommodate the recently modified mission plan.

Documents that describe the attributes of the MGS spacecraft are generally up-to-date.

MARS GLOBAL SURVEYOR (MGS)

BLOCK DICTIONARY

DOCUMENT NO. MCR-95-4129

DRD NO. SE009

CONTRACT NUMBER: 960048

3 JUNE 1997

REVISION: FINAL - REV 2

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BLOCK DICTIONARY

FOR THE
MARS GLOBAL SURVEYOR

15 August 1996
Revision: Final - Rev 1

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CHANGE LOG

MARTIN MARIETTA			**SPECIFICATION CHANGE LOG**	
Document Number: MCR-95-4129				
Document Title: Mars Global Surveyor Block Dictionary				
Change Number	**Change Date**	**Pages Affected**	**Authority Reference**	**Remarks**
Draft	Dec 1, 1994	All		
Draft (Update)	Jun 1, 1995	All	MU0039, MU0075	
Preliminary	Dec 15, 1995	All		
Final	Apr 1, 1996	All	MU0069, MT0120, MU0130, MU0152, MT0191, MU0222, MT0223, MU0234	
Final - Rev 1	Aug 15, 1996	All	MU0273, MU0296	
Final - Rev 2	Jun 3, 1997	4-81 to 4-146	MCR 105	

FOREWORD

This Block Dictionary is submitted to the Jet Propulsion Laboratory (JPL) under Contract Number 960048, Mars Global Surveyor, in accordance with Data Requirement Description (DRD) Sequence Number SE009.

Table of Contents

Table of Contents

Table of Contents

List of Figures and Tables

1. PURPOSE AND SCOPE

The primary purpose of this document is to define the set of spacecraft commands, referred to as Blocks, which control the spacecraft for the purpose of meeting mission objectives. This document will also provide the necessary information to the JPL sequencing software to assist in the generation of command sequences to be uplinked to the spacecraft. Included are spacecraft bus activities and interactive payload activities (involving spacecraft resources or more than one instrument) necessary to perform spacecraft events.

2. APPLICABLE DOCUMENTS

2.1 Lockheed Martin Documents

Document Number	Title
MCR-94-4119	Spacecraft Performance and Interface Specification
MCR-95-4130	Engineering Telemetry Dictionary
MCR-95-4143	Command Dictionary
MCR-95-4131	Flight Rules and Constraints
MCR-94-4137	Spacecraft Launch Event Timeline

2.2 JPL Documents

The following document is not contractually binding on the Lockheed Martin spacecraft design, nor the MOS documents. It does, however, provide guidance to the content of this document and provides the top-level view of mission activities to be accomplished by the blocks.

Document Number	Title
542-405	Mars Global Surveyor Mission Plan
542-407	Mars Global Surveyor Mission Sequence Plan

3. BLOCK OVERVIEW

A block is a discrete spacecraft-level activity which requires a time-ordered series of commands for execution. The commands within a block may span all spacecraft subsystems.

3.1 Block Development

Blocks will be developed to support the test and execution of command sequences derived from the operational requirements of the spacecraft as identified in the Spacecraft Performance and Interface Specification document (MCR-94-4119), subject to the rules and constraints documented in the Flight Rules and Mission Constraints document (MCR-95-4131).

3.2 Block Use in Flight Operations

Except for real-time commanding and spacecraft emergencies, flight operational sequences are expected to be implemented using validated blocks, supplemented by non-block individual commands as required.

3.3 Spacecraft Blocks

These blocks document nominal operations of spacecraft equipment for all mission phases. In some cases, the block is intended for a single use only (e.g., LAUNCH, PRIMER, HGADPLY). In these cases, the blocks need not be coded into Sequencing software, but are documented here for guidance in sequence preparation. The spacecraft blocks are contained in Section 4 of this dictionary.

3.4 Payload Blocks

These blocks document nominal operations of payload equipment for all applicable mission phases. The payload blocks are contained in Section 5 of this dictionary.

3.5 Recovery Blocks

Failure modes effects and criticality analyses (FMECA) performed during the design phase of S/C subsystems have demonstrated the need for pre-defined recovery plans. Some of these plans could result in the development of pre-defined blocks to address emergency situations. There are no recovery blocks planned for MGS. However, if recovery blocks are developed, they will be documented in this dictionary.

3.6 Block Implementation

Blocks will be implemented on-board the spacecraft using Scripts. A Script is a command macro containing relevant timing information, stored in on-board memory, which may be reused by updating the associated time tag. The time tag is the mechanism provided to the spacecraft to trigger stored command execution. A complete description of Scripts can be found in the Engineering Telemetry and Command Dictionaries (MCR-95-4130 and MCR-95-4143, respectively).

3.7 Block Documentation Format

Every block consists of 3 or 4 parts:

1) Block Description / Constraints text section
2) Parameter Table (except LAUNCH block)
3) Event Table
4) State Table (optional)

3.7.1 Block Description and Constraints

The Description / Constraints section contains a complete description of the block, including:

1) The purpose of the block, the phases of the mission in which block execution may occur, and a chronological description of the events.
2) The constraints which need to be checked prior to block execution to ensure proper execution of the block and/or to avoid hazardous actions to the spacecraft during execution.

3.7.2 Parameter Table

The Parameter Table contains information describing the parameters associated with a given block. A parameter is a variable whose value affects the characteristics and/or behavior of a block. Examples of a parameter may be the choice of a particular piece of equipment, the execution time of a command, or the request to perform a type of action. Parameters are used within blocks to make blocks more flexible in their use. Block parameterization helps to:

1) Expand the scope of the block by introducing a wider range of operations through the use of parameters.
2) Expand the functionality of the block using options.
3) Increase the control over block execution.
4) Decrease the number of blocks required to meet planned mission activity.

The table is divided into eight columns:

1) Number
2) Name
3) Source
4) Type
5) Units
6) Range
7) Default
8) Definition

3.7.2.1 Number

The parameter number is a unique number which identifies the parameter within a given block. The integer portion of the number is used to group together parameters having a similar source (e.g., Operator Input, Project Data Base, or Calculated). The decimal portion allows additional parameters to be easily appended to the block as required. If a parameter is deleted from the block, the parameter number associated with the deleted parameter will not be reused. If a parameter is added to the block, the parameter number associated with the added parameter will be one greater than the parameter number associated with the current last parameter in the table.

If that number had been previously associated with a deleted parameter, then the next available non-assigned parameter number will be used.

3.7.2.2 Name

The parameter name is a meaningful name assigned to each parameter in a given block.

3.7.2.3 Source

The source identifies the point of origin of the value assigned to each parameter. There are five sources for parameter value generation:

1) INPUT - The parameter value is supplied by operator entry.
2) PDB - The parameter value is supplied via an electronic query to the Project Data Base.
3) CALC - The parameter value is calculated based on any combination of Input, Project Data Base, and other Calculated parameters.
4) FSW - The parameter value is supplied autonomously by the flight software.
5) SEQ - The parameter value is a script buffer address supplied by the ground sequence software.

3.7.2.4 Type

The parameter type designates a parameter to be of a particular category (e.g. time related, logic flag, programming variable). There are 7 parameter types:

1) TIME - An absolute time used to indicate the time associated with a particular event.
2) DUR - A length of time which identifies the duration of an event.
3) OFF - A time offset used to indicate the start time of an event in terms of a reference time used within the block.
4) FLAG - A logic flag used to turn on/off any number of events in a block.
5) INT - An integer type representing a number with no decimal places.
6) REAL - A real type representing a number which allows decimals places.
7) CHAR - A character type representing a string of alphanumeric characters.

3.7.2.5 Units

A determinate quantity adopted as the standard unit of measurement for a given parameter.

3.7.2.6 Range

The parameter range is the permissible set of values for a parameter. The range may either be specified as limits or actual elements of the set of possible values.

3.7.2.7 Default

Where appropriate, input parameters will have associated default values. These default values will be the initial and/or most likely value for a given parameter, and is the value a parameter is assigned in the absence of an entered value. Because of the nature of PDB and calculated parameters, no default values are assigned to them.

3.7.2.8 Definition

Statements which define the parameter and its use in greater detail. If calculated parameters exist for a given block, the Definition column contains the derivation of those parameters. This derivation contains logical and algebraic expressions, algorithms, and/or diagrams which define the calculated parameters.

3.7.2.9 Option Table

An option table may be used for some blocks to facilitate the selection of input parameters. The table consists of sets of predetermined parameter selections which encompass the range of activity options available within the block.

3.7.3 Event Table

The Event Table contains information which describes the sequence of events during block execution. The table is divided into six columns:

1) Number
2) Event Sequence
3) Box Side
4) Symbol/Command
5) Timing
6) Description

3.7.3.1 Number

The event number is a unique number which identifies the event within a given block. The integer portion of the number is used to group together events having a similar function (e.g., Attitude Control, Recorder Management).

3.7.3.2 Event Sequence

The Event Sequence section presents the flow of activity experienced during block execution. The flow is described in a form similar to pseudo-code in which constructs such as loops, logic tests, assignments, and functions are used to produce the required block activity. However, unlike pseudo-code, the event sequence captures the lowest level of activity, namely the individual commands.

The pseudo-code convention is as follows:

1) Programming statements are expressed in upper case (e.g., REPEAT).
2) Commands are expressed in lower case (e.g., turn on modulation).
3) Parameters are expressed in upper case (e.g., REC_SEL).
4) Autonomous flight software activity is expressed in *italics*.

3.7.3.3 Box Side

Those spacecraft and payload devices with redundant sides or redundant units are identified by a unique parameter. These parameters will be defined to be 5 character names with a 3 character box mnemonic, an underscore, and the side designation (e.g., MOT_1, PDS_B). Selection of the parameter will reflect the current operating state of the device and ensure the issuance of the proper command.

3.7.3.4 Symbol/Command

Each line of pseudo-code in the event sequence is assigned a symbol/command. The symbols are assigned to those events which are non-commands and fall into 2 categories: those related to programming (i.e., loops, tests, assignments), and those which indicate activity occurring outside the block (i.e., flight software, ground, payload). The following represents the list of symbols available:

1) LOOP - Indicates the start or end of a loop.
2) TEST - Indicates a conditional test to determine whether or not subsequent action will follow.
3) ASSIGN - An assignment of the value of one variable to another.
4) STATE - Indicates the general condition of the block with respect to execution. The STATE may indicate the start, end, or wait status of block execution.
5) FSW - Represents an activity performed by flight software.
6) GDS - Represents an activity performed by the ground.
7) PAY - Indicates a payload activity not related to the spacecraft bus.

The commands are six character mnemonics which identify an individual command associated with a given subsystem device. Those devices which have redundant sides, as designated in the Box Side column, will have the mnemonics for both sides identified. These commands can be either hardware or software commands which affect any subsystem on the spacecraft. A complete list of commands can be found in the Command Dictionary (MCR-94-4143).

3.7.3.5 Timing

This section identifies the execution time associated with each event. The times are absolute but can be expressed in terms of other times using parameter time offsets, and/or durations. The timing of a block is usually anchored to one critical reference time (i.e., burn time for a maneuver block). A few exceptions may exist where block execution requires additional reference times.

3.7.3.6 Description

This section contains information which augments the information expressed by the event sequence pseudo-code. The information describes the action which results from event execution, including interaction with spacecraft equipment, timing and external groups, such as flight software and the ground.

3.7.4 Spacecraft State Table

Blocks may also have a spacecraft State Table, which lists the initial, transition and final states for the equipment within each subsystem (including the flight software). The list of subsystems and the respective equipment within each subsystem are not meant to be all inclusive, but rather those items which are directly relevant to the activity within the block. Some blocks are designed to be general purpose blocks, and a State Table is not applicable.

4. SPACECRAFT BLOCKS

These blocks are used to configure the spacecraft and perform routine or repetitive activities throughout the mission. They are listed in expected order of use in table 4-1, with the exception of the utility blocks, 4.12 through 4.14, which are expected to of use in any mission phase.

Table 4-1 List Of Spacecraft Blocks

No.	Block Name	Description	Mission Phase
4.1	LAUNCH	Launch Activities Block	Launch
4.2	PRIMER	Propulsion System Priming Block	Cruise
4.3	PRESSURE	Propulsion System Pressurization Block	Cruise/Orbit Insertion
4.4	MNVR	Main Engine or Thruster Maneuver Block	Cruise/Orbit Insertion
4.5	AEROBRAKE	Aerobraking Drag Pass Block	Orbit Insertion
4.6	ABM	Aerobraking Periapsis Maintenance Maneuver Block	Orbit Insertion
4.7	HGADPLY	High Gain Antenna Deployment Block	Orbit Insertion
4.8	MAPFIG	Mapping Configuration Block	Mapping
4.9	MAP_PB	Mapping Playback Block using Autonomous Eclipse Management	Mapping
4.10	MAP_RT	Mapping Realtime Communications Block using Autonomous Eclipse Management	Mapping
4.11	OTM	Mapping Orbit Maintenance Maneuver Block	Mapping
4.12	COMM	Realtime Communications Block	All
4.13	SSRMGR	Solid State Recorder Management Block	All
4.14	MANLOAD	Maneuver Parameter Load Block	All
4.15	BATT_MAN	Battery Management Block	Cruise, Orbit Insertion

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4.1 LAUNCH - Launch Activities Block

4.1.1 Block Description

This block is used to command the spacecraft throughout the launch phase. The launch sequence will be loaded onboard the spacecraft prior to liftoff, and control all activities from liftoff to the establishment of the Inner Cruise mission phase. There are two scripts within the block, one triggered by the launch detect breakwires and one triggered by the spacecraft separation detect breakwires (from the Delta third stage).

This block is intended for use only once, and need not be coded into the sequencing software. It is included here for documentation purposes. There are no parameters for this block since the spacecraft configuration is known and all events can be specified without options.

All events in the block are timed relative to one of the two detections. Full details regarding the launch events, definitions, timing and rationale, as well as the spacecraft prelaunch state (containing additional initial conditions for this block), are contained in the Spacecraft Launch Event Timeline document, MCR-94-4137.

The first event in the launch detect script is to turn on all twelve catbed heaters and enable all twelve thrusters to be used for attitude control after separation. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used. At the completion of the events, the flight software monitor for the launch detection script is disabled.

The first event in the separation detect script is to select the high rate mode for the IMU since it was configured to low rate for launch, and separation from the Delta third stage may result in significant tipoff rates.

The second event is to arm the thrusters which were enabled during the launch detection script. The attitude control subsystem software is set to the despin phase. Residual rates after the separation and yo-yo despin are then damped by commanding the spacecraft into the Despin/Deploy mode. This mode places the spacecraft into an inertially fixed position for solar array deployment.

All twelve thrusters and catbed heaters are then enabled again to ensure thruster availability in case launch was not detected.

After a one minute delay to allow the despin to complete, the third gyro is turned on by turning on all 3 gyros. (The spacecraft is launched with two of three gyros on). There are no software commands for turning on individual gyros, so this approach ensures that the fault protection software understands the power states of the gyros. REDMAN is then enabled to detect gyro faults. Note that there is a built-in delay of 70 seconds before faults on the newly powered third gyro will be detected. The built-in delay will also interrupt detection of faults on the other two gyros for 70 seconds. Gyro short recovery is also enabled at this time.

Next, two minutes after the latest time at which the despin was initiated, the attitude control subsystem software is set to the despin phase and the thrusters are disarmed for solar array deployment. The primary and secondary Pre-TCM pyro buses are enabled, the primary and secondary +Y solar array pyro buses are armed and the +Y array burnwires are fired, first the outboard left and right primary and secondary (simultaneously), then the inboard left and right primary and secondary (simultaneously) one second later. At the same time as the +Y array is released, the primary and secondary -Y solar array pyro buses are armed. One second later, the -Y array outboard left and right primary and secondary burnwires are fired. The -Y solar array inboard left and right primary and secondary burnwires follow one second later. One second later, the primary and secondary +Y solar array pyro buses are disarmed. Finally, the primary and secondary -Y solar array pyro buses are disarmed, and the primary and secondary Pre-TCM pyro buses are disabled. The timing of the disarms is driven by Flight Rule #0081-A-C&DH, which requires 6 seconds between commands which exercise opposite sides of a latching relay.

During the deployment, the solar array gimbal drive electronics are powered and solar array redundancy management is enabled. Approximately five minutes is allocated to deploy the panels, after which manual gimbal drive rate control is enabled. This action moves only the azimuth (outboard) gimbal of each panel to the preselected positions loaded into memory on the ground prior to launch. The azimuth gimbal is rotated first to avoid contact with the spacecraft. The AACS software is then set to the inner cruise mission phase. After a one minute delay to allow the panels to rotate out of plume impingement range, the thrusters are rearmed and the control system is allocated twenty seconds to damp out any rates induced by the deployment.

During the panel positioning activity, sun sensor redundancy management is enabled. Autonomous payload sun avoidance is then enabled and the AACS is commanded to the Sun-Comm-Power mode, which aligns the $+X_b$ axis along the sunline and begins a 0.01 rpm spin about that axis. This action also completes the positioning of the solar panels to their DSN acquisition positions, with the active sides angled 30° toward $+X_b$, by invoking the Contingency Mode positions stored onboard prior to launch. A maximum of ten minutes is expected for the sun search and slew to align the $+X_b$ axis to the sunline.

After Sun-Comm-Power initiation, several redundancy management options are enabled: control fault detection and response, thruster miscompare (i.e., leaky thruster) detection and response, Power Supply Electronics (PSE) redundancy management, Power Management Software (PMS) Contingency Alert, Battery Charge Regulator (BCR) switch for batteries 1 and 2, and PSE telemetry verification.

The TWTA launch turn-on software task is then enabled, which begins a 4 minute filament warmup for the upcoming DSN acquisition. This task configures the entire downlink RF path and is timed such that the TWTA beam will be powered on at the time of the latest possible end of eclipse in the launch period.

The fourth (skew) reaction wheel is then turned off, the fault protection software is told to select the XYZ wheel configuration, and the spacecraft is transitioned from thruster control to reaction wheel control. The thrusters are then disarmed and disabled and redundancy management enabled for the RWAs.

The instrument heaters and various spacecraft heaters are next enabled. The hydrazine tank heaters and the line heaters have an ‘enable’ relay upstream of the ‘on’ relay, and it is required that the ‘enable’ command precede the ‘on’ command for current rating purposes. Therefore, the ‘on’ command follows the ‘enable’ command by three seconds to preclude simultaneity.

Redundancy management is enabled for the TWTA 60 minutes after initiation of the launch TWTA turn-on to allow sufficient time for the TWTA to come on under worst case conditions.

During DSN Acquisition, thirty minutes prior to first use in Sun-Star-Init, the CSA is powered up.

After a two hour allocation to acquire the DSN, the $+Y_b$ solar panel Sun-Comm-Power Contingency Mode target angles are then set to their normal Cruise "lame duck" position, which will shade the spacecraft and prevent overcooling of the array. At the same time, the $-Y_b$ solar panel Contingency Mode target angles are set to their normal Cruise position, removing the DSN Acquisition offset.

The Sun-Star-Init attitude is then specified by selecting the late inner cruise pointing targets. These targets are a convenient location to store the desired attitude since MGS makes no distinction between early and late inner cruise as Mars Observer did. The attitude control state is then set to Sun-Star-Init, orienting the spacecraft $+X_b$ axis 60° from the sunline and spinning about the sunline at 0.01 rpm. Redundancy management for the CSA is enabled.

About 200 minutes is expected to be sufficient to establish inertial reference. The command to the standard cruise attitude control state, Array Normal Spin (ANS), is left for ground initiation to prevent a premature transition before inertial reference is established.

Five hours after acquiring the sun, battery temperature monitoring is enabled, allowing the batteries to be autonomously disconnected from the BCR when temperatures exceed 30°C. Two hours later the separation sequence actually does disconnect the batteries from the BCR, allowing sufficient time for the batteries to fully recharge after launch. Two hours later, the batteries are connected to the 0.18A float charge path circuit. This is the desired battery configuration used in cruise, with the exception of maneuvers and payload calibrations, to ensure the batteries will not overcharge and reach overtemperature limits that could threaten the health and life capacity of the batteries.

At the completion of the events, the flight software monitor for the separation detection script is disabled. The LAUNCH block terminates at this point.

To aid the user's understanding of this block, table 4.1.1-1 is provided to detail the attitude and articulation activities.

Table 4.1.1-1 LAUNCH Block AACS Events

Event	**Block Event No.**	**Mechanism**
Move the solar arrays away from the spacecraft following deployment.	10.4 & 10.5	Enable manual rate control. This causes the software to use the pad-loaded targets for the desired “azimuth only” motion.
Position the solar arrays for DSN Acquisition.	14.0	When Sun-Comm-Power is commanded, the FSW uses the target positions from the Contingency Mode preset data, whose initial values are pad-loaded to achieve this desired position.
Position the +Y solar array to the “lame duck” position, remove the -Y solar array DSN offset, and allow settling prior to Sun-Star-Init.	21.0	Load new Contingency Mode targets for Sun-Comm-Power.
Move the sun target so the spacecraft sweeps a 60 deg cone about the sun.	22.0	Select pad-loaded late inner cruise targets.
Position the +Y solar array to the “lame duck” position in Sun-Star-Init.	22.1	When Sun-Star-Init is commanded, the FSW uses the target positions from the Sun-Star-Init Contingency Mode preset data, whose initial values are pad-loaded to achieve this desired position. There is no physical panel motion as Event 21.0 already achieved the “lame duck” position.

4.1.2 Constraints

1. The spacecraft must be properly configured for launch per MCR-94-4137, Spacecraft Launch Event Timeline, and the appropriate ATLO Powerup Procedure.

2. Proper script addresses for the launch detection triggered script and for the separation detection triggered script must be supplied to the flight software launch and separation detection logic.

3. All 4 RWAs must be powered on and in tach hold mode at ≥200 rpm prior to launch.

4. Outer cruise sun pointing targets must be pre-selected prior to launch for DSN initial acquisition. The sun avoidance vector must be preset to $+Z_b$ prior to launch.

5. The primary LGA transmit antenna must be pre-selected. This block does not modify Two-Way Noncoherent Mode (TWNC), Ranging, or DOR, so they must be preset prior to launch in order to be configured correctly for DSN Acquisition.

6. SSR-1A must be powered on and begin recording prior to launch.

7. Two gyros must be powered on and in low rate mode prior to launch. The remaining gyro must be off. The two powered gyros are commanded to high rate at separation and the unpowered gyro is turned on one minute after separation, all by this block. When the third gyro is powered, it assumes high rate mode as well.
8. The Power Management software (charge rate control) and the Power Management fault protection must be enabled prior to launch.

9. The initial solar array target angles for DSN acquisition must be loaded onboard prior to launch.

10. Additional constraints are documented in MCR-94-4137, Spacecraft Launch Event Timeline.

11. The Sun-Star-Init Contingency Mode solar array target angles must be pre-selected prior to launch containing the “lame duck” orientation data.

12. The necessary non-stored commanding after LAUNCH block completion is listed below. None of this commanding is required within the first two days after launch.
    - Load targets for ANS
    - Go to ANS mode
    - Position solar panels for ANS
    - Enable momentum unloads
    - Enable propulsion ΔT heaters
    - Enable secondary cat bed heaters

Parameter Table (LAUNCH)

No parameters.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START LAUNCH DETECTION SCRIPT		STATE	T= LAUNCH_DETECT	Launch detection initiates pre-spacecraft separation command sequence.
2.0	enable REA & catbed heater no 1		PRC01E	T= LAUNCH_DETECT + 00:23:30	Warm up the primary catbed heaters for the 12 RCS thrusters, in order to allow immediate thruster firing after spacecraft separation from Delta 3rd stage. The secondary catbed heaters are disabled for launch to conserve power.
2.1	enable REA & catbed heater no 3		PRC03E		
2.2	enable REA & catbed heater no 5		PRC05E		
2.3	enable REA & catbed heater no 7		PRC07E		
2.4	enable REA & catbed heater no 9		PRC09E		
2.5	enable REA & catbed heater no 12		PRC12E		
2.6	enable REA & catbed heater no 2		PRC02E	T= LAUNCH_DETECT + 00:23:31	
2.7	enable REA & catbed heater no 4		PRC04E		
2.8	enable REA & catbed heater no 6		PRC06E		
2.9	enable REA & catbed heater no 8		PRC08E		
2.10	enable REA & catbed heater no 10		PRC10E		
2.11	enable REA & catbed heater no 11		PRC11E		
3.0	disable launch sequence monitor		SCLSMX	T= LAUNCH_DETECT + 00:23:32	Disable the flight software monitor for the launch detection script.
4.0	END LAUNCH DETECTION SCRIPT		STATE		

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START SEPARATION DETECT SCRIPT		STATE	T= SEP_DETECT (Corresponds to Launch + ~49 Minutes nominally, with a range of 43:38 to 55:38 over the launch period)	Spacecraft/Delta 3rd stage separation detection initiates post-spacecraft separation command sequence.
2.0	select IMU high rate mode		SCIMUH	T= SEP_DETECT	Place gyros in high rate mode to minimize chances of saturation in X and Y axes.
3.0	arm REAs 1,3,5,7,9,12		PRTHOA	T= SEP_DETECT + 00:00:01	Arm odd thrusters for post-separation despin.
3.1	arm REAs 2,4,6,8,10,11		PRTHEA		Arm even thrusters for post-separation despin.
4.0	set AACS mission phase to “despin”		SASMPH		Command the AACS software to the despin mission phase.
4.1	set attitude control state to "despin/deploy”		SAGDPL		Command the AACS state to "despin/deploy" control to damp the residual spin rate after the Delta yo-yo despin to zero. Yo-Yo despin will decrease spacecraft spin rate from 60 rpm to under 2 rpm.
5.0	enable REA & catbed heater no 1		PRC01E	T= SEP_DETECT + 00:00:02	Reissue the enable odd REA thruster commands in the event the launch detection script was not initiated due to a breakwire detection failure.
5.1	enable REA & catbed heater no 3		PRC03E		
5.2	enable REA & catbed heater no 5		PRC05E		
5.3	enable REA & catbed heater no 7		PRC07E		
5.4	enable REA & catbed heater no 9		PRC09E		
5.5	enable REA & catbed heater no 12		PRC12E		

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.6	enable REA & catbed heater no 2		PRC02E	T= SEP_DETECT + 00:00:03	Reissue the enable even REA thruster commands in the event the launch detection script was not initiated due to a breakwire detection failure.
5.7	enable REA & catbed heater no 4		PRC04E		
5.8	enable REA & catbed heater no 6		PRC06E		
5.9	enable REA & catbed heater no 8		PRC08E		
5.10	enable REA & catbed heater no 10		PRC10E		
5.11	enable REA & catbed heater no 11		PRC11E		
6.0	*spin up reaction wheels to 200 rpm and command tach hold*		*FSW*		*In despin/deploy control, the RWAs are maintained at 200 rpm in tach hold mode.*
6.1	*fire thrusters to remove residual yo-yo despin rate and to hold current attitude*		*FSW*		*The appropriate RCS thrusters are fired to reduce the yo-yo despin residual rate to 0.25 °/sec and to hold the current estimated attitude.*
6.2	*read quaternion to determine current attitude*		*FSW*		*Despin/deploy control software will read and control the spacecraft to the current quaternion under thruster control (attitude after rates are damped).*
7.0	turn on gyro #2		SRAGYP	T= SEP_DETECT + 00:01:00	All three gyros are commanded on in order to turn #2 on. This approach preserves REDMAN's knowledge of the gyro power state.
7.1	enable REDMAN (gyros)		SCREDN		Enable gyro fault detection. REDMAN will wait 70 seconds before processing fault data for gyro #2.
7.2	enable gyro short recovery		SRNGRE	T= SEP_DETECT + 00:02:07	Enable the "long" gyro short recovery logic.
7.3	set AACS mission phase to "sad_deploy"		SASMPH		Command the AACS software to the deploy mission phase.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.0	disarm REAs 1,3,5,7,9,12		PRTHOD	T= SEP_DETECT + 00:02:07	After approximately two minutes for despin completion, the thrusters are disarmed for the solar array deployment. Attitude control is normally maintained with the thrusters in despin/deploy mode. However, it is desired to inhibit any torque on the spacecraft during the solar array deployment, so the thrusters are disarmed for the five minutes required for deployment.
8.1	disarm REAs 2,4,6,8,10,11		PRTHED		
9.0	enable primary pre-TCM pyro bus		PYPTPE	T= SEP_DETECT + 00:02:08	Enable the primary pyro bus for the +Yb solar array deployment.
9.1	enable backup pre-TCM pyro bus		PYPTSE		Enable the backup pyro bus for the +Yb solar array deployment.
9.2	arm primary pyro bus for SAP pyros		PYSPPA	T= SEP_DETECT + 00:02:09	Arm the primary pyro bus for the +Yb solar array deployment.
9.3	arm backup pyro bus for SAP pyros		PYSPSA		Arm the backup pyro bus for the +Yb solar array deployment.
9.4	fire SAP primary left and right outboard burnwires		PYPOBP	T= SEP_DETECT + 00:02:10	Fire +Y SA primary left and right outboard burnwires to release the outer panel.
9.5	fire SAP secondary left and right outboard burnwires		PYPOBS		Fire +Y SA secondary left and right outboard burnwires to release the outer panel.
9.6	fire SAP primary left inboard burnwire		PYPILP	T= SEP_DETECT + 00:02:11	Fire +Y SA primary left inboard burnwire to release the inner panel.
9.7	fire SAP primary right inboard burnwire		PYPIRP		Fire +Y SA primary right inboard burnwire to release the inner panel.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
9.8	fire SAP secondary left inboard burnwire		PYPILS	T= SEP_DETECT + 00:02:11	Fire +Y SA secondary left inboard burnwire to release the inner panel.
9.9	fire SAP secondary right inboard burnwire		PYPIRS		Fire +Y SA secondary right inboard burnwire to release the inner panel.
	+Y Solar Array released				
9.10	arm primary pyro bus for SAM pyros		PYSMAA		Arm the primary pyro bus for the -Yb solar array deployment.
9.11	arm backup pyro bus for SAM pyros		PYSMBA		Arm the backup pyro bus for the -Yb solar array deployment.
9.12	fire SAM primary left and right outboard burnwires		PYMOBP	T= SEP_DETECT + 00:02:12	Fire -Y SA primary left and right outboard burnwires to release the outer panel.
9.13	fire SAM secondary left and right outboard burnwires		PYMOBS		Fire -Y SA secondary left and right outboard burnwires to release the outer panel.
9.14	fire SAM primary left inboard burnwire		PYMILP	T= SEP_DETECT + 00:02:13	Fire -Y SA primary left inboard burnwire to release the inner panel.
9.15	fire SAM primary right inboard burnwire		PYMIRP		Fire -Y SA primary right inboard burnwire to release the inner panel.
9.16	fire SAM secondary left inboard burnwire		PYMILS		Fire -Y SA secondary left inboard burnwire to release the inner panel.
9.17	fire SAM secondary right inboard burnwire		PYMIRS		Fire -Y SA secondary right inboard burnwire to release the inner panel.
	-Y Solar Array released				

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
9.18	disarm primary pyro bus for SAP pyros		PYSPPD	T= SEP_DETECT + 00:02:15	Disarm the primary pyro bus for the +Yb solar array deployment.
9.19	disarm backup pyro bus for SAP pyros		PYSPSD		Disarm the backup pyro bus for the +Yb solar array deployment.
9.20	disarm primary pyro bus for SAM pyros		PYSMAD	T= SEP_DETECT + 00:02:17	Disarm the primary and backup pyro bus for the -Y solar array deployment.
9.21	disarm backup pyro bus for SAM pyros		PYSMBD		
9.22	disable primary pre-TCM pyro bus		PYPTPX		Disable the primary and backup pyro bus for the -Y solar array deployment.
9.23	disable backup pre-TCM pyro bus		PYPTSX		
10.0	power on +Y solar array gimbal drive electronics		SRSP1N	T= SEP_DETECT + 00:06:39	Power on +Y and -Y SA gimbal drive electronics in preparation for moving the panels to their positions for DSN acquisition.
10.1	power on -Y solar array gimbal drive electronics		SRSM1N		
10.2	enable REDMAN (+Y solar array)		SCREDN	T= SEP_DETECT + 00:07:08	Enable +Yand -Y solar array gimbal fault detection.
10.3	enable REDMAN (-Y solar array)		SCREDN		
10.4	enable +Yb solar array manual gimbal drive rate control		SAPRCE	T= SEP_DETECT + 00:07:09	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays. Will move inboard and outboard gimbals to the target angles preloaded prior to launch. These targets are selected such that only the azimuth gimbal motion is commanded.
10.5	enable -Yb solar array manual gimbal drive rate control		SAMRCE		
10.6	set AACS mission phase to “inner_cruise”		SASMPH	T= SEP_DETECT + 00:07:10	Command the AACS software to the inner cruise mission phase.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
11.0	arm REAs 1,3,5,7,9,12		PRTHEA	T= SEP_DETECT + 00:08:08	Rearm the thrusters and resume thruster control after allowing one minute for the solar panels to move out of plume impingement range. Allow at least 20 seconds for the thrusters to damp out the spacecraft body rates due to the deployment.
11.1	arm REAs 2,4,6,8,10,11		PRTHOA		
12.0	enable REDMAN (SSAs)		SCREDN	T= SEP_DETECT + 00:08:20	Enable sun sensor fault detection.
13.0	enable autonomous payload sun avoidance		SAAVDE	T= SEP_DETECT + 00:08:30	Enable autonomous sun avoidance logic for the payload prior to acquiring the DSN acquisition attitude. Assumes avoidance vector pre-set to be the +Zb vector.
14.0	set attitude control state to "sun comm pwr"		SAGSCP		S/C will perform sun acquisition, align the spacecraft +Xb axis with the sun-line and initiate a 0.01 rpm spin about the sun-line. Assumes the sun coning mode pointing targets are pre-set to the outer cruise sun pointing targets. At the transition from deploy control to sun-comm-power, the articulation targets for the +Y and -Y SA gimbals are also changed from the “overhead” deployment targets (loaded in the “nominal” target buffer during prelaunch init) to a special target (loaded into the sun-comm-power target buffer during prelaunch init) similar to cruise but lowered slightly below the XY plane to allow a stronger LGT1 signal for DSN acquisition.
14.1	enable REDMAN (control fault response)		SCREDN		Enable REDMAN attitude control fault response.
14.2	enable REDMAN (thruster miscompare response)		SCREDN		Enable REDMAN thruster miscompare fault response.
14.3	enable control fault detection		SAACFE	T= SEP_DETECT + 00:08:31	Enable REDMAN attitude control fault detection.
14.4	enable leaky thruster detection		SAALTE		Enable REDMAN leaky thruster detection.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
14.5	enable REDMAN (PSE)		SCREDN	T= SEP_DETECT + 00:08:32	Enable REDMAN for the Power Supply Electronics (PSE).
14.6	enable contingency alert		SWCOAE		Enables Power Management Software (PMS) contingency alert. When state of charge for both batteries drops below load shed threshold, PMS will perform load shedding and switch to the backup Mode Controller. Also requests contingency mode entry if contingency mode is armed.
14.7	enable BCR switch for battery 1		SWBS1E	T= SEP_DETECT + 00:08:33	Enable autonomous switch to backup BCR for both batteries.
14.8	enable BCR switch for battery 2		SWBS2E		
14.9	enable PSE telemetry verification		SWTLVE	T= SEP_DETECT + 00:08:34	Enable PSE telemetry verification.
15.0	enable launch TWTA turn on sequence		STLRPT	T= SEP_DETECT + 00:17:31	Initiate the initial TWTA launch turn on sequence for DSN acquisition. The telecom task will warm up the TWTA filament, wait 4 minutes, and configure the transmit RF path. In the process, the exciter is turned on. This event is timed such that the TWTA beam comes on in sunlight, at the time of the latest possible eclipse end in the launch period.
16.0	turn off skew reaction wheel		ARWASF	T= SEP_DETECT + 00:21:31	Prior to switching to RWA control, power off the skew reaction wheel.
16.1	select XYZ RWA configuration		SRUXYZ		After powering off the skew wheel, re-select the XYZ reaction wheel configuration, to prevent an unnecessary bus side swap in the event redundancy management had detected a failure in one of the three orthogonal wheels and switched to a skew wheel configuration.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
16.2	set nominal actuator select flag to RWA control		SAASFW	T= SEP_DETECT + 00:21:31	After selecting the proper wheel configuration and allowing sufficient time to find the sun and to slew the +X axis to the sun (8 minutes after latest eclipse exit) on thrusters, actuator control is switched from thrusters to the reaction wheels.
16.3	set contingency actuator select flag to RWA control		SAACMW		Actuator control for contingency mode entry is switched from thrusters to reaction wheels.
17.0	disarm REAs 1,3,5,7,9,12		PRTHOD		Disarm thrusters after switching to reaction wheel control.
17.1	disarm REAs 2,4,6,8,10,11		PRTHED		
17.2	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= SEP_DETECT + 00:21:32	Disable thrusters after switching to reaction wheel control.
17.3	disable REAs & catbed heaters no 2,4,6		PRCTBX		
17.4	disable REAs & catbed heaters no 7,9,12		PRCTCX		
17.5	disable REAs & catbed heaters no 8,10,11		PRCTDX		
18.0	enable REDMAN (RWAs)		SCREDN		Enable REDMAN for the reaction wheels after switching to reaction wheel control.
19.0	enable / power on spacecraft heaters:				Except propulsion ΔT heaters and secondary cat bed heaters which will be enabled by non-stored command several days into cruise. The HGA cable heaters will be used only just prior to HGA deployment. In some cases, the secondary DTCs are chosen for initial usage to avoid an SPF.
19.0.1	- EM panels		THXMSE THXPSE THYPSE	T= SEP_DETECT + 00:21:35	Enable secondary DTCs.
19.0.2	- dampers		THHDPE THHDSE	T= SEP_DETECT + 00:21:36	Enable thermostatic heaters.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.3	- main engine		THMEPE	T= SEP_DETECT + 00:21:37	Enable primary DTC.
19.0.4	- MHSA		THHSSE		Enable secondary DTC.
19.0.5	- valves		THP1PE THP2PE THVCPE	T= SEP_DETECT + 00:21:38	Enable primary DTC and enable thermostatic heaters.
19.0.6	- tanks and fuel & ox lines (enable)		THTNPE THTNSE THLHPE THLHSE	T= SEP_DETECT + 00:21:40	Enable primary tank heater DTC. Also close one of two tank heater relays for secondary DTC such that FP can swap properly if necessary. Enable line heaters. These heaters have an enable relay upstream of the on relay, and it is required that the enable command precede the on command for current rating purposes. Therefore, the on command follows by three seconds in the next event.
19.0.7	- tanks and fuel & ox lines (on)		THTNPN THLHPN THLHSN THLOPN THLOSN	T= SEP_DETECT + 00:21:43	Turn on heaters. See previous event.
19.1	enable DTC fault protection word 2 set to 0xFFFF		SHRTDE	T= SEP_DETECT + 00:21:44	Enable heater DTC fault detection.
19.2	enable / power on instrument heaters				Replacement or survival heaters. Current thermal analysis indicates the Magnetometer sensors could overheat in the early cruise environment if their heaters were turned on. Therefore, the IMHTRN is not issued in this event, but should be commanded later in cruise.
19.2.1	*- turn on ER replacement heater*		IEHTRN	T= SEP_DETECT + 00:21:45	

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.2.2	*- turn on MOC replacement heater*		ICHTMN	T= SEP_DETECT + 00:21:46	
19.2.3	*- turn on MOLA replacement heater*		ILHTRN	T= SEP_DETECT + 00:21:47	
19.2.4	*- turn on TES replacement heater*		ITHTRN	T= SEP_DETECT + 00:21:48	
	DSN Acquisition				*Spacecraft will remain in DSN initial acquisition attitude and configuration for 2 hours.*
20.0	enable REDMAN (TWTAs)		SCREDN	T= SEP_DETECT + 01:17:31	Enable TWTA fault detection 60 minutes after initiation of launch TWTA turn on to allow sufficient time for the beam to come on under worst case.
21.0	turn on CSA fan A and fan B		SRCFAN SRCFBN	T= SEP_DETECT + 01:58:19	Power on the CSA 30 minutes prior to commanding the AACS to "sun star init".
22.0	load +Yb solar array contingency mode gimbal drive target angles outboard azimuth gimbal angle set to -0.48869 radians inboard elevation gimbal angle set to 0.0 radians		SALPCT	T= SEP_DETECT + 02:21:32	Load the +Yb solar array contingency mode target angles for the gimbal rotation to the lame duck position.
22.1	load -Yb solar array contingency mode gimbal drive target angles outboard azimuth gimbal angle set to -0.48869 radians inboard elevation gimbal angle set to +1.5708 radians		SALMCT	T= SEP_DETECT + 02:21:33	Load the -Yb solar array contingency mode target angles for the gimbal rotation to the cruise position (removes DSN acquisition offset).

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
23.0	select late inner cruise pointing targets		SAULIT	T= SEP_DETECT + 02:21:34	The DSN acquisition attitude is maintained for 2 hours, after which the spacecraft is commanded to initiate the sequence to acquire the lame duck cruise attitude. The first step is to acquire the inner cruise sun coning attitude. New inner cruise sun pointing mode targets are loaded to allow this attitude acquisition. In both "sun comm pwr" and "sun star init" attitude control states, the spacecraft will align the +Xb axis 60° from the sun and spin about the sun vector at 0.01 rpm.
23.1	set attitude control state to "sun star init"		SAGSSI	T= SEP_DETECT + 02:28:19	Go to the "sun star init" attitude control state. Spacecraft will be oriented to the attitude defined in the previous step. Star identification is enabled in this mode. The maximum time to establish inertial reference is about 200 minutes or two rotations about the sun line. The actual time will depend on the number of stars in the catalog for the defined attitude.
23.2	enable REDMAN (CSA)		SCREDN	T= SEP_DETECT + 02:28:20	Enable CSA fault detection after CSA warmup.
24.0	enable battery temperature monitor control		SWB1TE SWB2TE	T= SEP_DETECT + 05:21:31	Five hours after latest sun acquisition time, enable battery temperature monitor control. Will disconnect batteries from the charge path if temperatures exceed 30° C.
24.1	disconnect battery charge path (both batteries) address = h2464 dataword = h8440		SISERC	T= SEP_DETECT + 07:21:31	After seven hours of battery charging, both batteries are disconnected from the charge path to prevent battery overheating.
24.2	enable 0.18A trickle charge circuit for both batteries		PWB1TE PWB2TE	T= SEP_DETECT + 09:21:31	Two hours after disconnecting the batteries from the charge path, enable the 0.18A trickle charge circuit to both batteries.

Event Table (LAUNCH)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
24.3	turn on 0.18A trickle charge circuit for both batteries		PWB1TN PWB2TN	T= SEP_DETECT + 09:21:32	Turn on the 0.18A trickle charge circuit to both batteries.
25.0	disable separation sequence monitor		SCSEPX	T= SEP_DETECT + 09:21:33	Disable the flight software monitor for the separation detection script, upon completion of the script.
26.0	END SEPARATION DETECTION SCRIPT		STATE		

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4.2 PRIMER - Propulsion Subsystem Priming Block

4.2.1 Block Description

This block is used to vent and wet the bipropellant lines prior to TCM-1. The fuel and oxidizer lines below the latch valves LV4 and LV5 contain a blanket helium pressure of about 50 psia at launch. The lines upstream of these latch valves contain propellants at about 100 psia at launch. At the completion of the execution of this block, fuel and oxidizer are present down to the main engine valves MEV1 and MEV2. The propulsion subsystem is shown schematically in figure 4.2.1-1.

This block is intended for use only once, and need not be coded into the sequencing software. It is included here for documentation purposes.

All events in the block are timed relative to the start of the priming event.

The first event in the block is to enable and arm the main engine valves, both primary and secondary. The valves are then opened for 30 seconds to allow the helium venting to complete. Thirty seconds is well within the capability of the valves to remain energized without convective cooling. The valves are then closed, disarmed and disabled.

The next event is to enable and arm latch valves LV4 and LV5, open both valves for 30 seconds to wet the downstream lines, and then close, disarm, and disable the valves. Closing these latch valves protects against a main engine valve leak.

Upon completion of this block, the propulsion subsystem is ready for pressurization, which is performed by the PRESSURE block.

4.2.2 Constraints

1. This block is to be executed only once during the mission, prior to the first execution of the PRESSURE block.

2. The block SSRMGR shall be executed in conjunction with this block to record engineering telemetry during the priming event.

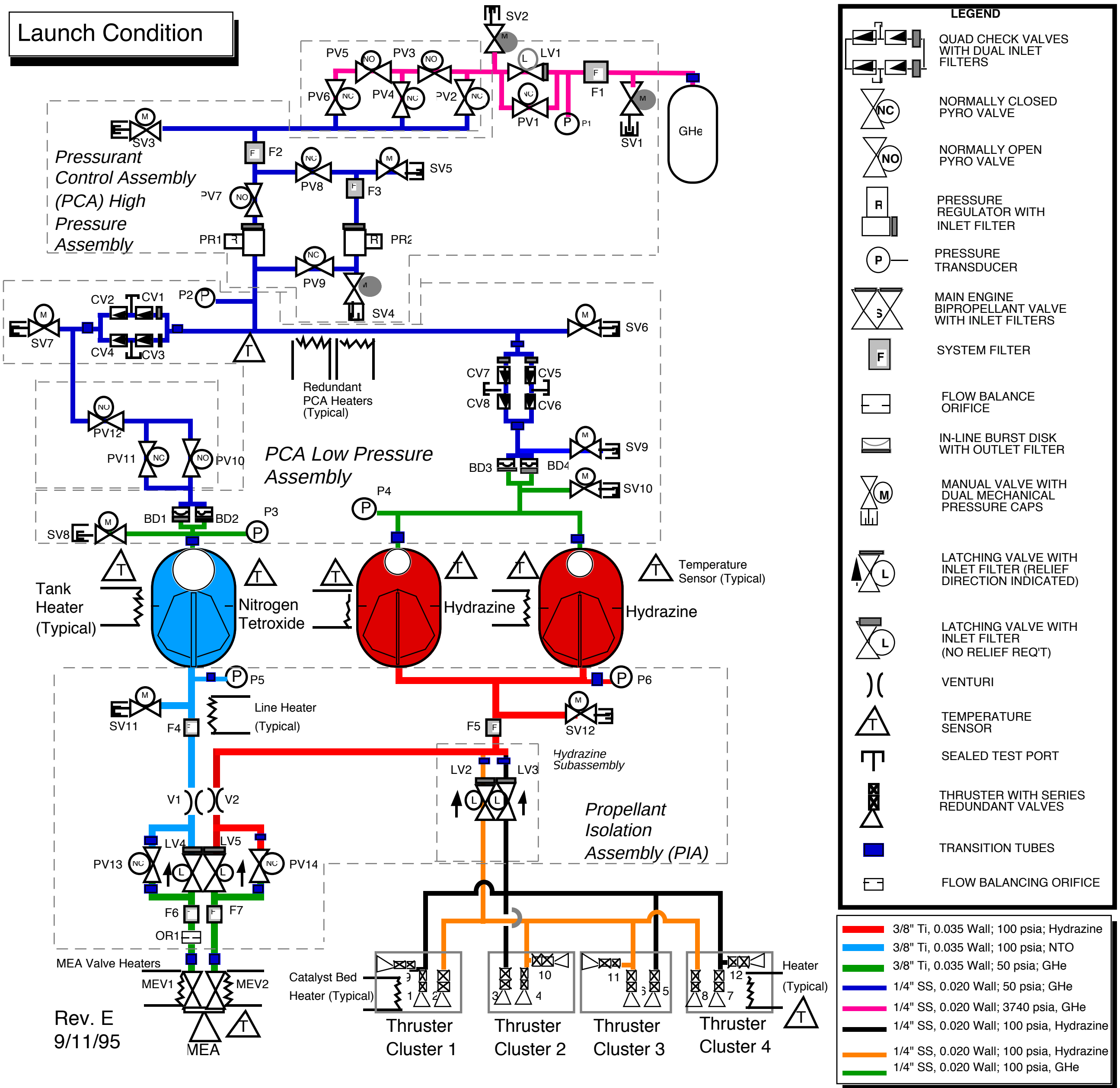

Figure 4.2.1-1 Propulsion Subsystem Schematic - Launch Condition

Parameter Table (PRIMER)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	PRIME_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired start time for the bipropellant system priming event. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
2.0							No PDB parameters for this block.
3.0							No calculated parameters for this block.

Event Table (PRIMER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of PRIMER block execution.
2.0	enable main engine valve primary		PRMEPE	T= PRIME_START	Enable main engine valves, primary and secondary.
2.1	enable main engine valve secondary		PRMESE		
2.2	arm main engine valve primary		PRMEPA	T= PRIME_START + 00:00:01	Enable main engine valves, primary and secondary.
2.3	arm main engine valve secondary		PRMESA		
2.4	fire main engine valve primary		PRMEPR	T= PRIME_START + 00:00:04	Open main engine valves, primary and secondary, to evacuate the blanket helium pressure in the lines for the launch event. Note that latch valves 4 and 5, which allow the oxidizer and hydrazine, respectively, to flow down to the engines, are closed during the launch phase of the mission.
2.5	fire main engine valve secondary		PRMESR		
2.6	close main engine valve primary		PRMEPF	T= PRIME_START + 00:00:34	Close the main engine valves, primary and secondary, after allowing 30 seconds for the venting.
2.7	close main engine valve secondary		PRMESF		
2.8	disarm main engine valve primary		PRMEPD	T= PRIME_START + 00:00:37	Disarm main engine valves, primary and secondary, after the venting event.
2.9	disarm main engine valve secondary		PRMESD		
2.10	disable main engine valve primary		PRMEPX	T= PRIME_START + 00:00:38	Disable main engine valves, primary and secondary, after the venting event.
2.11	disable main engine valve secondary		PRMESX		

Event Table (PRIMER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0	enable latch valve 4		PRL04E	T= PRIME_START + 00:01:00	Enable latch valve 4 in preparation for wetting the main engine lines down to the engine valves.
3.1	enable latch valve 5		PRL05E	T= PRIME_START + 00:01:01	Enable latch valve 5 in preparation for wetting the main engine lines down to the engine valves.
3.2	arm latch valve 4		PRL04A	T= PRIME_START + 00:01:02	Arm latch valve 4.
3.3	arm latch valve 5		PRL05A	T= PRIME_START + 00:01:03	Arm latch valve 5.
3.4	open latch valve 4		PRL04O	T= PRIME_START + 00:01:05	Open latch valves 4 and 5 to allow the oxidizer and hydrazine, respectively, to flow down to the main engine valves.
3.3	open latch valve 5		PRL05O	T= PRIME_START + 00:01:06	
3.4	close latch valve 4		PRL04C	T=PRIME_START + 00:01:15	Latch valves 4 and 5 are closed, after allowing 10 seconds for the main engine lines to be wetted, in order to protect against a main engine valve leak.
3.5	close latch valve 5		PRL05C	T=PRIME_START + 00:01:16	
3.6	disarm latch valve 4		PRL04D	T= PRIME_START + 00:01:18	Latch valves 4 and 5 are disarmed and disabled.
3.7	disarm latch valve 5		PRL05D	T= PRIME_START + 00:01:19	
3.8	disable latch valve 4		PRL04X	T= PRIME_START + 00:01:20	
3.9	disable latch valve 5		PRL05X	T= PRIME_START + 00:01:21	
4.0	END BLOCK		STATE		End of PRIMER block execution.

State Table (PRIMER)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Propulsion				
	Main engine valves 1 & 2	closed, disarmed, & disabled	opened, armed, enabled	closed, disarmed, & disabled
	Biprop latch valves 4 & 5	closed, disarmed, & disabled	opened, armed, enabled	closed, disarmed, & disabled

4.3 PRESSURE - Propulsion Subsystem Pressurization Block

4.3.1 Block Description

This block is used to pyrotechnically pressurize, isolate, and un-isolate portions of the propulsion subsystem throughout the mission. Isolation is used to prevent migration of oxidizer vapor to undesired areas and to prevent a possible leaking regulator from overpressurizing the fuel tanks. Contingency options are included to bypass failed latch valves or a failed primary regulator. Another option allows repressurization of the fuel tanks for increased performance. This block must be executed individually for each option desired.

All events in the block are timed relative to the start of the pressurization event.

The first event in the block is to warmup the catbed heaters of the thrusters to be used while under thruster control. Depending on the configuration of the propulsion system, the block has an option to use all twelve of the thrusters or, in the event of a half-side latch out, either the odd or even string of thrusters. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used.

The next event in the block is to turn on the unused skew reaction wheel assembly (RWA) if necessary. RWAs can be damaged by pyro events if not spinning at 200 rpm or greater. An input parameter in the block identifies whether the skew wheel is being used. If it is off, it is powered on by the block. If it is already on, one of the orthogonal wheels has probably failed and should not be turned on. If one of the orthogonal wheels had been turned off because it exhibited undesirable behavior but is worth preserving, it should be turned on by realtime command outside this block. Once the appropriate RWAs are powered, the Despin/Deploy AACS control state will hold all RWAs to a specified (parameter) constant speed.

Next, the thrusters are armed and the thruster configuration flag is set for the desired thruster configuration to be used for attitude control, according to the input flag selecting odd, even, or both strings.

Thruster control is selected and the AACS control state is set to Despin/Deploy for the pyro event.

The propulsion subsystem is shown schematically in figure 4.2.1-1. Figure 4.3.1-1 contains a schematic of the pyro bus configuration. The next event is to perform one of eight nominal pyro events (presented in expected mission phase order):

1) Open normally closed pyro valve 6 to pressurize the propulsion system prior to the first main engine maneuver;
2) Isolate the oxidizer from the rest of the system by closing normally open pyro valve 10;
3) Isolate the pressurant from the rest of the system by closing normally open pyro valve 5. Activities 2 and 3 are expected to be performed at the beginning of the first long wait between main engine maneuvers during cruise;
4) Un-isolate the oxidizer from the rest of the system by opening normally closed pyro valve 11;
5) Repressurize the propulsion system by opening normally closed pyro valve 4. Activities 4 and 5 are expected to be performed prior to the MOI main engine maneuver;
6) Isolate the oxidizer from the rest of the system by closing normally open pyro valve 12;
7) Isolate the pressurant from the rest of the system by closing normally open pyro valve 3. Activities 6 and 7 are expected to be performed after the final main engine maneuver;

8) Repressurize the hydrazine system, if necessary, by opening normally closed pyro valve 2.

One of five contingency pyro events can be performed:

9) Bypass failed closed latch valve 1 by opening normally closed pyro valve 1 to allow pressurization;
10) Bypass failed closed latch valve 4 by opening normally closed pyro valve 13 to allow oxidizer to flow to the main engine;
11) Bypass failed closed latch valve 5 by opening normally closed pyro valve 14 to allow fuel to flow to the main engine;
12) Isolate the primary regulator in the event of a leak, by closing normally open pyro valve 7;
13) Bring the backup regulator on line in the event of a leak in the primary regulator, by opening normally closed pyro valves 9 and 8. These valves are fired in that order to maximize the ullage volume downstream of the regulator.

Each pyro event consists of commands to enable and arm the appropriate pyro bus, fire the pyro valve(s), and disarm and disable the pyro bus. This block must be called separately for each valve to be fired, except for the two valves which switch in the backup regulator. When both a pressurant and a propellant valve are to be fired in the same timeframe, the pressurant valve should normally be fired first. Each fire command (primary and secondary) energizes *both* NSIs in the pyro valve. There is no delay required between issuing the primary and secondary commands.

The next events in the block are to re-enable reaction wheel control, disarm and disable the thrusters and their catbed heaters, and restore the AACS control state to Array Normal Spin.

A 10 minute delay is then observed to allow telemetry from the skew wheel to be processed by the AACS flight software as it spins down. The final events in the block restore the pre-block RWA configuration, if appropriate, by turning off the skew wheel and configuring redundancy management to use the remaining three wheels. Without the REDMAN command, an unnecessary swapping of the CIU bus would occur in the event one of the three orthogonal wheels were to actually fail during the pyro firing activities, since REDMAN would believe there were two failed wheels instead of one when the skew wheel was turned off.

4.3.2 Constraints

1. Prior to the execution of PRESSURE for the first time, the block PRIMER must be executed to vent and wet the bipropellant lines.

2. The block SSRMGR shall be executed in conjunction with this block to record engineering telemetry during the pressurization event.

3. The IMU must be in high rate mode.

4. The tach hold RWA speeds are set to the desired values for the pyro event within this block.

5. When communications are possible during these pyro events, the LGA shall be selected via the COMM Block prior to the execution of the PRESSURE Block, since HGA communications cannot be reliably maintained while on thruster control.

6. Prior to exercising the PV8_9_OPN option of this block (to bring the backup regulator on-line), the ground shall either isolate the primary regulator (using the PV7_CLS option of this block) by command, or verify that the fault protection has autonomously done so already in response to a prior fault, since it is undesirable to operate the pressurized system under the control of two regulators simultaneously.

7. When exercising any of the options within this block that would bring the regulator on-line (PV1_OPN, PV2_OPN, PV4_OPN, PV6_OPN and PV8_9_OPN), the ground shall first enable overpressure fault protection logic 1. This algorithm will close LV1 in the event of a regulator leak that exceeds a ground specified value.

8. When exercising any of the options within this block that would bring the regulator on-line (PV1_OPN, PV2_OPN, PV4_OPN, PV6_OPN and PV8_9_OPN), and the ground desires to have overpressure fault protection logic 2 enabled (autonomous pyro isolation of the primary regulator in the event of a regulator leak that exceeds a ground specified value), then this logic shall only be left enabled while on thruster control. Upon transitioning back to wheel control in this block, this algorithm shall be disabled to prevent damage to the wheels. Additionally the value of the RWA_DLY parameter in this block, for switching back to reaction wheel control, shall be set sufficiently large to ensure that thruster control is maintained until the tanks have stabilized at their desired operating pressure.

9. Prior to execution of this block, the BATT_MAN block shall be executed to connect the batteries to the BCR to prevent a possible failure in which a single wire were to open due to the shock of firing the pyro valve, causing loss of control of the charge path select relays for the battery.

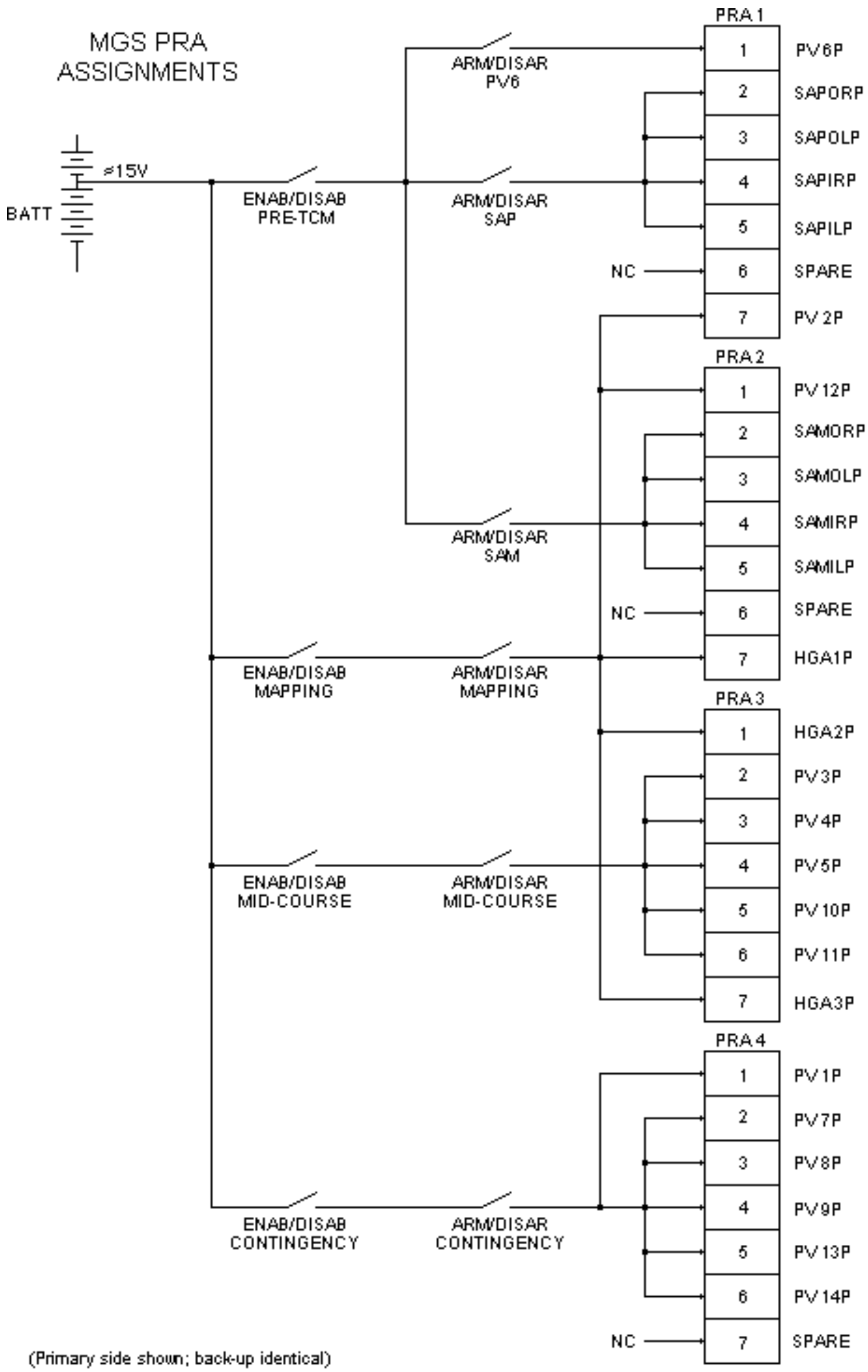

Figure 4.3.1-1 Pyro Bus Configuration

Parameter Table (PRESSURE)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	PRESS_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired start time to fire pyro valves for the pressurization event. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	OPTION	INPUT	CHAR	N/A	PV6_OPN PV5_CLS PV10_CLS PV4_OPN PV11_OPN PV3_CLS PV12_CLS PV2_OPN PV1_OPN PV13_OPN PV14_OPN PV7_CLS PV8_9_OPN	N/A	Parameter used to select the desired pyro firing option. OPTION PV6_OPN is used to open normally closed pyro valve 6 to pressurize the propulsion system prior to the first main engine maneuver. OPTION PV5_CLS is used to perform the first isolation of the helium pressurant from the rest of the system by closing normally open pyro valve 5. OPTION PV10_CLS is used to perform the first isolation of the oxidizer side from the rest of the system by closing normally open pyro valve 10 OPTION PV4_OPN is used to perform the first repressurization of the propulsion system by opening normally closed pyro valve 4. OPTION PV11_OPN is used to perform the first un-isolation of the oxidizer side from the rest of the system by opening normally closed pyro valve 11. OPTION PV3_CLS is used to perform the second isolation of the helium pressurant from the rest of the system by closing normally open pyro valve 3. OPTION PV12_CLS is used to perform the second isolation of the oxidizer side from the rest of the system by closing normally open pyro valve 12. (continued on next page)

Parameter Table (PRESSURE)

No	Name	Source	Type	Units	Range	Default	Definition
1.2	OPTION (continued)	INPUT	CHAR	N/A	PV6_OPN PV5_CLS PV10_CLS PV4_OPN PV11_OPN PV3_CLS PV12_CLS PV2_OPN PV1_OPN PV13_OPN PV14_OPN PV7_CLS PV8_9_OPN	N/A	OPTION PV2_OPN is used to perform the second repressurization of the propulsion system by opening normally closed pyro valve 2. OPTION PV1_OPN is a contingency option used to open normally closed pyro valve 1, in the event latch valve 1 fails closed. OPTION PV13_OPN is a contingency option used to open normally closed pyro valve 13, in the event latch valve 4 fails closed. OPTION PV14_OPN is a contingency option used to open normally closed pyro valve 14, in the event latch valve 5 fails closed. OPTION PV7_CLS is a contingency option used to isolate the primary regulator in the event of a leak, by closing normally open pyro valve 7. OPTION PV8_9_OPN is a contingency option used to bring the backup regulator on line in the event of a leak, by opening normally closed pyro valves 8 and 9.
1.3	S_RWA	INPUT	CHAR	N/A	'OFF' 'ON'	'OFF'	Parameter used to determine whether the skew RWA is currently powered off, and thus not being used for attitude control. This will ensure that the skew RWA is turned on during the block execution for safing during the pyro firing event, and turned off again when the event has been completed. If an orthogonal RWA had failed previously, the skew wheel will already be powered on and its will not be changed in this block. If an orthogonal RWA had previously behaved erratically and was shut off, but it is still desired to turn it on to safe it for the pyro firing event, then it must be powered on and off externally to this block.

Parameter Table (PRESSURE)

No	Name	Source	Type	Units	Range	Default	Definition
1.4	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, prior to usage. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes.
1.5	REA_SELECT	INPUT	CHAR	N/A	BOTH ODD EVEN	BOTH	Selects desired REA thruster configuration for control. Normally set to BOTH, to use both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be used.
1.6	X_WHL_SPD_INIT	INPUT	INT	wcounts (1 wcount = 5 rpm)	-600 to 600	+40	Parameter used to set desired X RWA tach hold speeds to be maintained during the pyro event.
1.7	Y_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	-40	Parameter used to set desired Y RWA tach hold speed to be maintained during the pyro event.
1.8	Z_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+40	Parameter used to set desired Z RWA tach hold speed to be maintained during the pyro event.
1.9	S_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+69	Parameter used to set desired skew RWA tach hold speed to be maintained during the pyro event.
1.10	RWA_DLY	INPUT	DUR	hh:mm:ss	00:00:40 - 01:00:00	00:00:40	Parameter used to determine when to switch back to reaction wheel control after the pyro firing event. Normally set to 40 seconds. If the intended use of this block is to bring the regulator on-line (OPTION = PV1_OPN, PV2_OPN, PV4_OPN, PV6_OPN, and PV8_9_OPN), and the ground intends to enable overpressure fault protection logic 2 to autonomously pyro isolate the regulator in the event of a regulator leak, then the value of RWA_DLY shall be set sufficiently large to ensure that thruster control is maintained until after the tanks have stabilized at the desired operating pressure. This will ensure that the reaction wheels will not be damaged in the event of a leak, due to the autonomous pyro firing.
2.0							No PDB parameters for this block.

Parameter Table (PRESSURE)

No	Name	Source	Type	Units	Range	Default	Definition
3.0	REA_ODD	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the odd string of thrusters (1,3,5,7,9,12) is to be enabled and armed. Calculated from the REA thruster configuration selection, Parameter No. 1.5, REA_SELECT. IF (REA_SELECT = BOTH OR ODD) THEN REA_ODD = TRUE
3.1	REA_EVEN	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the even string of thrusters (2,4,6,8,10,11) is to be enabled and armed. Calculated from the REA thruster configuration selection, Parameter No. 1.5, REA_SELECT. IF (REA_SELECT = BOTH OR EVEN) THEN REA_EVEN = TRUE

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of PRESSURE block execution.
2.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), normally 30 min prior to usage.
2.0.1	enable REA & turn on catbed htr no 1		PRC01E	T = PRESS_START - CATBED_DUR - 00:00:01	
2.0.2	enable REA & turn on catbed htr no 3		PRC03E		
2.0.3	enable REA & turn on catbed htr no 5		PRC05E		
2.0.4	enable REA & turn on catbed htr no 7		PRC07E		
2.0.5	enable REA & turn on catbed htr no 9		PRC09E		
2.0.6	enable REA & turn on catbed htr no 12		PRC12E		
2.1	END IF		TEST		
2.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) normally 30 min prior to usage.
2.2.1	enable REA & turn on catbed htr no 2		PRC02E	T = PRESS_START - CATBED_DUR	
2.2.2	enable REA & turn on catbed htr no 4		PRC04E		
2.2.3	enable REA & turn on catbed htr no 6		PRC06E		
2.2.4	enable REA & turn on catbed htr no 8		PRC08E		
2.2.5	enable REA & turn on catbed htr no 10		PRC10E		
2.2.6	enable REA & turn on catbed htr no 11		PRC11E		
2.3	END IF		TEST		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.4	IF (S_RWA = OFF) THEN		TEST	T = PRESS_START - 00:01:10	Only three RWAs (nominally the three orthogonal RWAs) are powered on for attitude control. If the skew wheel is powered off, it could potentially be damaged if it is not powered on and spinning during the pyro firing events. Thus it is turned on to safe it for the pyro firing event. If the skew wheel is already on, one of the orthogonal wheels has probably failed and should not be turned on. If one of the orthogonal wheels had been turned off because it exhibited undesirable behavior but is worth preserving, it should be turned on by realtime command outside this block.
2.4.1	turn on skew RWA		ARWASN		
2.5	END IF		TEST		
2.6	IF (REA_ODD) THEN		TEST		Re-enable the selected thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off and the thrusters disarmed & disabled.
2.6.1	enable REA & catbed heater no 1		PRC01E	T = PRESS_START - 00:01:04	
2.6.2	enable REA & catbed heater no 3		PRC03E		
2.6.3	enable REA & catbed heater no 5		PRC05E		
2.6.4	enable REA & catbed heater no 7		PRC07E		
2.6.5	enable REA & catbed heater no 9		PRC09E		
2.6.6	enable REA & catbed heater no 12		PRC12E		
2.6.7	arm REAs 1,3,5,7,9,12		PRTHOA	T = PRESS_START - 00:01:02	
2.7	END IF		TEST		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.8	IF (REA_EVEN) THEN		TEST		
2.8.1	enable REA & catbed heater no 2		PRC02E	T= PRESS_START - 00:01:03	
2.8.2	enable REA & catbed heater no 4		PRC04E		
2.8.3	enable REA & catbed heater no 6		PRC06E		
2.8.4	enable REA & catbed heater no 8		PRC08E		
2.8.5	enable REA & catbed heater no 10		PRC10E		
2.8.6	enable REA & catbed heater no 11		PRC11E		
2.8.7	arm REAs 2,4,6,8,10,11		PRTHEA	T= PRESS_START - 00:01:02	
2.9	END IF		TEST		
3.0	set actuator select flag to thruster control		SAASFT	T= PRESS_START - 00:01:02	Transition to thruster control for the pyro firing.
3.1	set tach hold wheel speed X_WHL_SPD_INIT Y_WHL_SPD_INIT Z_WHL_SPD_INIT S_WHL_SPD_INIT		SALFWS	T= PRESS_START - 00:01:01	Specify desired wheel speed to be maintained during the pyro event. If the current wheel speed is greater than WHL_SPD_INIT, the current speed is left unchanged.
3.2	set AACS control state to despin/deploy		SAGDPL	T= PRESS_START - 00:01:00	The flight software will command all RWAs to hold constant at the selected speed.

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0	IF (OPTION = PV6_OPN) THEN		STATE		OPTION PV6_OPN is used to open normally closed pyro valve 6 to pressurize the propulsion system prior to the first main engine maneuver.
4.0.1	enable primary pre-TCM pyro bus		PYPTPE	T = PRESS_START - 00:00:04	
4.0.2	enable secondary pre-TCM pyro bus		PYPTSE		
4.0.3	arm primary pyro valve 6 pyro bus		PYP6PA	T = PRESS_START - 00:00:03	
4.0.4	arm secondary pyro valve 6 pyro bus		PYP6SA		
4.0.5	fire primary pyro valve 6		PYV06P	T = PRESS_START	
4.0.6	fire secondary pyro valve 6		PYV06S	T = PRESS_START	
4.0.7	disarm primary pyro valve 6 pyro bus		PYP6PD	T = PRESS_START + 00:00:03	
4.0.8	disarm secondary pyro valve 6 pyro bus		PYP6SD		
4.0.9	disable primary pre-TCM pyro bus		PYPTPX	T = PRESS_START + 00:00:04	
4.0.10	disable secondary pre-TCM pyro bus		PYPTSX		
4.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	IF (OPTION = PV5_CLS) THEN		STATE		OPTION PV5_CLS is used to perform the first isolation of the helium pressurant from the rest of the system by closing normally open pyro valve 5.
5.0.1	enable primary mid course pyro bus		PYMDPE	T= PRESS_START - 00:00:04	
5.0.2	enable secondary mid course pyro bus		PYMDSE		
5.0.3	arm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPA	T= PRESS_START - 00:00:03	
5.0.4	arm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSA		
5.0.5	fire primary pyro valve 5		PYV05P	T= PRESS_START	
5.0.6	fire secondary pyro valve 5		PYV05S	T= PRESS_START	
5.0.7	disarm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPD	T= PRESS_START + 00:00:03	
5.0.8	disarm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSD		
5.0.9	disable primary mid course pyro bus		PYMDPX	T= PRESS_START + 00:00:04	
5.0.10	disable secondary mid course pyro bus		PYMDSX		
5.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0	IF (OPTION = PV10_CLS) THEN		STATE		OPTION PV10_CLS is used to perform the first isolation of the oxidizer side from the rest of the system by closing normally open pyro valve 10.
6.0.1	enable primary mid course pyro bus		PYMDPE	T = PRESS_START - 00:00:04	
6.0.2	enable secondary mid course pyro bus		PYMDSE		
6.0.3	arm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPA	T = PRESS_START - 00:00:03	
6.0.4	arm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSA		
6.0.5	fire primary pyro valve 10		PYV10P	T = PRESS_START	
6.0.6	fire secondary pyro valve 10		PYV10S	T = PRESS_START	
6.0.7	disarm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPD	T = PRESS_START + 00:00:03	
6.0.8	disarm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSD		
6.0.9	disable primary mid course pyro bus		PYMDPX	T = PRESS_START + 00:00:04	
6.0.10	disable secondary mid course pyro bus		PYMDSX		
6.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0	IF (OPTION = PV4_OPN) THEN		STATE		OPTION PV4_OPN is used to perform the first repressurization of the propulsion system by opening normally closed pyro valve 4.
7.0.1	enable primary mid course pyro bus		PYMDPE	T = PRESS_START - 00:00:04	
7.0.2	enable secondary mid course pyro bus		PYMDSE		
7.0.3	arm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPA	T = PRESS_START - 00:00:03	
7.0.4	arm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSA		
7.0.5	fire primary pyro valve 4		PYV04P	T = PRESS_START	
7.0.6	fire secondary pyro valve 4		PYV04S	T = PRESS_START	
7.0.7	disarm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPD	T = PRESS_START + 00:00:03	
7.0.8	disarm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSD		
7.0.9	disable primary mid course pyro bus		PYMDPX	T = PRESS_START + 00:00:04	
7.0.10	disable secondary mid course pyro bus		PYMDSX		
7.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.0	IF (OPTION = PV11_OPN) THEN		STATE		OPTION PV11_OPN is used to perform the first un-isolation of the oxidizer side from the rest of the system by opening normally closed pyro valve 11.
8.0.1	enable primary mid course pyro bus		PYMDPE	T = PRESS_START - 00:00:04	
8.0.2	enable secondary mid course pyro bus		PYMDSE		
8.0.3	arm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPA	T = PRESS_START - 00:00:03	
8.0.4	arm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSA		
8.0.5	fire primary pyro valve 11		PYV11P	T = PRESS_START	
8.0.6	fire secondary pyro valve 11		PYV11S	T = PRESS_START	
8.0.7	disarm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPD	T = PRESS_START + 00:00:03	
8.0.8	disarm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSD		
8.0.9	disable primary mid course pyro bus		PYMDPX	T = PRESS_START + 00:00:04	
8.0.10	disable secondary mid course pyro bus		PYMDSX		
8.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
9.0	IF (OPTION = PV3_CLS) THEN		STATE		OPTION PV3_CLS is used to perform the second isolation of the helium pressurant from the rest of the system by closing normally open pyro valve 3.
9.0.1	enable primary mid course pyro bus		PYMDPE	T = PRESS_START - 00:00:04	
9.0.2	enable secondary mid course pyro bus		PYMDSE		
9.0.3	arm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPA	T = PRESS_START - 00:00:03	
9.0.4	arm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSA		
9.0.5	fire primary pyro valve 3		PYV03P	T = PRESS_START	
9.0.6	fire secondary pyro valve 3		PYV03S	T = PRESS_START	
9.0.7	disarm primary mid course pyro bus (PVs 3,4,5,10,11)		PYMDPD	T = PRESS_START + 00:00:03	
9.0.8	disarm secondary mid course pyro bus (PVs 3,4,5,10,11)		PYMDSD		
9.0.9	disable primary mid course pyro bus		PYMDPX	T = PRESS_START + 00:00:04	
9.0.10	disable secondary mid course pyro bus		PYMDSX		
9.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
10.0	IF (OPTION = PV12_CLS) THEN		STATE		OPTION PV12_CLS is used to perform the second isolation of the oxidizer side from the rest of the system by closing normally open pyro valve 12.
10.0.1	enable primary mapping pyro bus		PYMPPE	T = PRESS_START - 00:00:04	
10.0.2	enable secondary mapping pyro bus		PYMPSE		
10.0.3	arm primary mapping pyro bus (PVs 2 & 12)		PYMPPA	T = PRESS_START - 00:00:03	
10.0.4	arm secondary mapping pyro bus (PVs 2 & 12)		PYMPSA		
10.0.5	fire primary pyro valve 12		PYV12P	T = PRESS_START	
10.0.6	fire secondary pyro valve 12		PYV12S	T = PRESS_START	
10.0.7	disarm primary mapping pyro bus (PVs 2 & 12)		PYMPPD	T = PRESS_START + 00:00:03	
10.0.8	disarm secondary mapping pyro bus (PVs 2 & 12)		PYMPSD		
10.0.9	disable primary mapping pyro bus		PYMPPX	T = PRESS_START + 00:00:04	
10.0.10	disable secondary mapping pyro bus		PYMPSX		
10.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
11.0	IF (OPTION = PV2_OPN) THEN		STATE		OPTION PV2_OPN is used to perform the second repressurization of the propulsion system by opening normally closed pyro valve 2.
11.0.1	enable primary mapping pyro bus		PYMPPE	T= PRESS_START - 00:00:04	
11.0.2	enable secondary mapping pyro bus		PYMPSE		
11.0.3	arm primary mapping pyro bus (PVs 2 & 12)		PYMPPA	T= PRESS_START - 00:00:03	
11.0.4	arm secondary mapping pyro bus (PVs 2 & 12)		PYMPSA		
11.0.5	fire primary pyro valve 2		PYV02P	T= PRESS_START	
11.0.6	fire secondary pyro valve 2		PYV02S	T= PRESS_START	
11.0.7	disarm primary mapping pyro bus (PVs 2 & 12)		PYMPPD	T= PRESS_START + 00:00:03	
11.0.8	disarm secondary mapping pyro bus (PVs 2 & 12)		PYMPSD		
11.0.9	disable primary mapping pyro bus		PYMPPX	T= PRESS_START + 00:00:04	
11.0.10	disable secondary mapping pyro bus		PYMPSX		
11.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
12.0	IF (OPTION = PV1_OPN) THEN		STATE		OPTION PV1_OPN is a contingency option used to open normally closed pyro valve 1, in the event latch valve 1 fails closed.
12.0.1	enable primary contingency pyro bus		PYCPPE	T= PRESS_START - 00:00:04	
12.0.2	enable secondary contingency pyro bus		PYCPSE		
12.0.3	arm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPA	T= PRESS_START - 00:00:03	
12.0.4	arm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSA		
12.0.5	fire primary pyro valve 1		PYV01P	T= PRESS_START	
12.0.6	fire secondary pyro valve 1		PYV01S	T= PRESS_START	
12.0.7	disarm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPD	T= PRESS_START + 00:00:03	
12.0.8	disarm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSD		
12.0.9	disable primary contingency pyro bus		PYCPPX	T= PRESS_START + 00:00:04	
12.0.10	disable secondary contingency pyro bus		PYCPSX		
12.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
13.0	IF (OPTION = PV13_OPN) THEN		STATE		OPTION PV13_OPN is a contingency option used to open normally closed pyro valve 13, in the event latch valve 4 fails closed.
13.0.1	enable primary contingency pyro bus		PYCPPE	T= PRESS_START - 00:00:04	
13.0.2	enable secondary contingency pyro bus		PYCPSE		
13.0.3	arm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPA	T= PRESS_START - 00:00:03	
13.0.4	arm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSA		
13.0.5	fire primary pyro valve 13		PYV13P	T= PRESS_START	
13.0.6	fire secondary pyro valve 13		PYV13S	T= PRESS_START	
13.0.7	disarm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPD	T= PRESS_START + 00:00:03	
13.0.8	disarm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSD		
13.0.9	disable primary contingency pyro bus		PYCPPX	T= PRESS_START + 00:00:04	
13.0.10	disable secondary contingency pyro bus		PYCPSX		
13.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
14.0	IF (OPTION = PV14_OPN) THEN		STATE		OPTION PV14_OPN is a contingency option used to open normally closed pyro valve 14, in the event latch valve 5 fails closed.
14.0.1	enable primary contingency pyro bus		PYCPPE	T= PRESS_START - 00:00:04	
14.0.2	enable secondary contingency pyro bus		PYCPSE		
14.0.3	arm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPA	T= PRESS_START - 00:00:03	
14.0.4	arm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSA		
14.0.5	fire primary pyro valve 14		PYV14P	T= PRESS_START	
14.0.6	fire secondary pyro valve 14		PYV14S	T= PRESS_START	
14.0.7	disarm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPD	T= PRESS_START + 00:00:03	
14.0.8	disarm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSD		
14.0.9	disable primary contingency pyro bus		PYCPPX	T= PRESS_START + 00:00:04	
14.0.10	disable secondary contingency pyro bus		PYCPSX		
14.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
15.0	IF (OPTION = PV7_CLS) THEN		STATE		OPTION PV7_CLS is a contingency option used to isolate the primary regulator in the event of a leak, by closing normally open pyro valve 7.
15.0.1	enable primary contingency pyro bus		PYCPPE	T = PRESS_START - 00:00:04	
15.0.2	enable secondary contingency pyro bus		PYCPSE		
15.0.3	arm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPA	T = PRESS_START - 00:00:03	
15.0.4	arm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSA		
15.0.5	fire primary pyro valve 7		PYV07P	T = PRESS_START	
15.0.6	fire secondary pyro valve 7		PYV07S	T = PRESS_START	
15.0.7	disarm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPD	T = PRESS_START + 00:00:03	
15.0.8	disarm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSD		
15.0.9	disable primary contingency pyro bus		PYCPPX	T = PRESS_START + 00:00:04	
15.0.10	disable secondary contingency pyro bus		PYCPSX		
15.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
16.0	IF (OPTION = PV8_9_OPN) THEN		STATE		OPTION PV8_9_OPN is a contingency option used to bring the backup regulator on line in the event of a leak, by opening normally closed pyro valves 9 then 8.
16.0.1	enable primary contingency pyro bus		PYCPPE	T = PRESS_START - 00:00:04	
16.0.2	enable secondary contingency pyro bus		PYCPSE		
16.0.3	arm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPA	T = PRESS_START - 00:00:02	
16.0.4	arm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSA		
16.0.5	fire primary pyro valve 9		PYV09P	T = PRESS_START	
16.0.6	fire secondary pyro valve 9		PYV09S	T = PRESS_START	
16.0.7	fire primary pyro valve 8		PYV08P	T = PRESS_START + 00:00:10	
16.0.8	fire secondary pyro valve 8		PYV08S	T = PRESS_START + 00:00:10	
16.0.9	disarm primary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPPD	T = PRESS_START + 00:00:12	
16.0.10	disarm secondary contingency pyro bus (PVs 1,7,8,9,13,14)		PYCPSD		
16.0.11	disable primary contingency pyro bus		PYCPPX	T = PRESS_START + 00:00:14	
16.0.12	disable secondary contingency pyro bus		PYCPSX		
16.1	END IF		STATE		

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
17.0	set actuator select flag to reaction wheel control		SAASFW	T= PRESS_START + RWA_DLY	Transition back to wheels.
17.1	disarm REAs 1,3,5,7,9,12		PRTHOD	T= PRESS_START + RWA_DLY + 00:00:01	Disarm all of the REAs.
17.2	disarm REAs 2,4,6,8,10,11		PRTHED		
17.3	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= PRESS_START + RWA_DLY + 00:00:02	Disable all of the REAs and their catbed heaters.
17.4	disable REAs & catbed heaters no 2,4,6		PRCTBX		
17.5	disable REAs & catbed heaters no 7,9,12		PRCTCX		
17.6	disable REAs & catbed heaters no 8,10,11		PRCTDX		
18.0	set attitude control state to ANS		SAGANS	T= PRESS_START + RWA_DLY + 00:00:30	Return to Array Normal Spin.
19.0	IF (S_RWA = OFF) THEN		TEST		If the skew wheel was powered on for this block, is powered back off here. If the skew wheel was already on, it is left on. If one of the orthogonal wheels was turned on by realtime command outside this block because it exhibited undesirable behavior but was worth preserving, it should be turned back off by realtime command outside this block.
19.0.1	turn off skew RWA		ARWASF	T= PRESS_START + RWA_DLY + 00:10:30	Allow 10 minutes from the time ANS was re-enabled, before turning back off the RWA which is not being used for attitude control. This will ensure that the telemetry from that wheel will be processed by the AACS software for health and status as the wheel spins down to 0 rpm.

Event Table (PRESSURE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.2	use wheels XYZ		SRUXYZ	T = PRESS_START + RWA_DLY + 00:10:31	After turning off the skew RWA, re-command redundancy management to use the XYZ wheels. This will prevent unnecessary switching of the CIU bus in the event one of the three orthogonal wheels were to fail during the pyro firing event. Thus for example, if the Y wheel were to fail and then the skew wheel was turned back off after the sequence, then REDMAN would believe there were two failed wheels and would switch buses.
19.1	END IF		TEST		
20.0	END BLOCK		STATE		End of PRESSURE block execution.

State Table (PRESSURE)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	RWAs	skew wheel off[1]	all wheels on at ≥ specified rpm.	skew wheel off[1]
Propulsion[2]				
	Pyro valve 6	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 5	open, disarmed, & disabled	armed, enabled & fired	closed, disarmed, & disabled
	Pyro valve 10	open, disarmed, & disabled	armed, enabled & fired	closed, disarmed, & disabled
	Pyro valve 4	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 11	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 3	open, disarmed, & disabled	armed, enabled & fired	closed, disarmed, & disabled
	Pyro valves 12	open, disarmed, & disabled	armed, enabled & fired	closed, disarmed, & disabled
	Pyro valve 2	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 1	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 13	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 14	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Pyro valve 7	open, disarmed, & disabled	armed, enabled & fired	closed, disarmed, & disabled
	Pyro valves 8 & 9	closed, disarmed, & disabled	armed, enabled & fired	open, disarmed, & disabled
	Thrusters[3]	disabled and disarmed	enabled, armed, fired	disabled and disarmed
	Thruster catalyst bed heaters[3]	off	on	off

1 If the skew wheel is initially on, its configuration is not changed.
2 The initial, transition, and final states of the propulsion subsystem depend upon which of the thirteen block options is exercised.
3 The actual thrusters which will be used depend on the selection of odd, even, or both strings.

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4.4 MNVR - Main Engine and Thruster Maneuver Block

4.4.1 Block Description

MNVR controls the activities required to perform all cruise maneuvers, including the Mars orbit insertion maneuver. The block is used for either main engine or thruster burns, selectable via a parameter. Recording/playback of burn telemetry is performed by the SSRMGR block. Realtime communications, if available, are managed by the COMM block. The maneuver parameters are loaded using the MANLOAD block.

All events in the block are timed relative to the start of the engine or thruster flight software maneuver task.

The first event in the block is to warmup the catbed heaters of the thrusters to be used during the maneuver, either as the primary means of propulsion or as the means for attitude control during a main engine burn. Depending on the configuration of the propulsion system, the block has an option to use all twelve of the thrusters or, in the event of a half-side latch out, either the odd or even string of thrusters. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used.

In addition to the catbed heaters used for the thrusters, the main engine injector heater is also warmed up prior to the start of the burn. 60 minutes is normally required to warm up the main engine injector.

Attitude control is next commanded to the ISH mode to turn the spacecraft to the desired burn attitude (loaded in the MANLOAD block) under reaction wheel control. The turn to the burn attitude is accomplished in about 10 minutes for a worst case 180° turn. Autonomous sun avoidance protection remains enabled during the slew to the burn attitude, thereby ensuring the payload will not be pointed within 30 degrees of the sun. Since star processing is inhibited while in ISH mode, the AACS flight software sun ephemeris test is used to verify that the desired burn attitude has been achieved. For this test, the ephemeris generated sun vector in the inertial frame is converted to the S/C body frame based on the internally computed S/C attitude. If the angle between this vector and the measured sun vector from the sun sensor exceeds a chosen threshold (nominally 2°), then the AACS software will command to the sun acquisition and sun coning attitude control state ('Sun Comm Power') and the maneuver will be effectively aborted, since a maneuver can only be initiated from the ISH attitude control state.

For MOI, the command to force the inertial reference established flag (IRE) to “TRUE” within the attitude control software is also issued one second prior to the start of the turn in the anomalous event that inertial reference is not established. This will ensure that the turn will at least be attempted. In the best case the attitude errors may only be several degrees off and a successful MOI burn can still be accomplished. In the worst case, the burn will at least be attempted and not aborted.

Maneuvers will be automatically aborted if the body rate, angular acceleration, or attitude control error exceed ground commandable limits, or if the sun ephemeris test fails, unless the special MOI redundancy option described in the next paragraph is selected.

If the special MOI redundancy option is selected, the main engine will be disarmed when an excessive attitude error, rate, or angular acceleration is detected. Redundancy management software will determine whether the problem is in the IMU by switching the IMU to all gyro format and performing a gyro co-axis miscompare test. The maneuver will be restarted after a fixed delay to allow Gyro REDMAN to respond to potential IMU faults.

Once the spacecraft has begun the slew to the maneuver attitude, the solar arrays are oriented to their required positions for the burn. The position is selectable via parameter. For main engine burns, the solar arrays must be canted 30° towards the spacecraft $-Z_b$ axis in order to keep the gimbals against the hard stops while the spacecraft is accelerating. For thruster burns, there is no requirement to position the solar arrays against the hard stops for load reasons, but the S/C center of mass must be located properly. Since an array position against the hard stops satisfies the center of mass requirement, the same position is recommended for either main engine or thruster burns. The solar arrays are each commanded in the manual rate mode to an absolute inboard and outboard gimbal position.

Approximately two minutes prior to the start of the burn, the IMU is switched to the accelerometer output format, in which the IMU will output three channels of gyro data and three channels of accelerometer data to the flight software. The IMU must be in this format so the flight software maneuver task can process accelerometer telemetry from the IMU during the burn and determine delta V accumulation and maneuver cutoff time. Next, the IMU frozen gyro check is enabled. While the IMU is in accelerometer output format, the 6 gyro co-channel compare ability is not available. Thus a frozen gyro could be mission critical during a maneuver. Enabling the frozen gyro check allows the flight software to select the backup gyro axis and thus safely continue the burn if the gyro output is identical for 10 consecutive cycles. Next, an accelerometer calibration is performed. The accumulated delta V is first zeroed and then measured from each accelerometer over a selected period of time (nominally 100 seconds), to determine the accelerometer bias on each accelerometer.

A reaction wheel tach hold option exists for main engine maneuvers, in which a set of ground defined wheel speeds are loaded and maintained throughout the burn while on thruster control. If this option is not selected then the wheels will be held at their current speeds upon initiation of thruster control. This option is provided primarily for MOI to protect the reaction wheels from pyro shock damage when tank underpressure and overpressure detection logic may be enabled, resulting in possible autonomous pyro firings to correct the anomalous condition. If this option is selected then the skew reaction wheel will be turned on (if not already in use) and spun up to 200 rpm when control is switched to thrusters.

Fifteen seconds prior to a main engine burn, redundancy management for the engine DCT#7 heaters is disabled, since heat soakback from the engine would cause REDMAN to believe that the primary heater had failed on, triggering a swap to the redundant heater. The main engine is then enabled and armed and latch valves 4 and 5 are opened. At burn minus 4 seconds, the thrusters are re-enabled and their catbed heaters turned on, in the event an emergency momentum unloading was autonomously performed during the slew to the burn attitude. An emergency unload would have resulted in the thrusters being disarmed and disabled and the heaters being turned off by the flight software. At burn start minus two seconds, the thrusters are armed. One second prior to the start of the burn, the maneuver type flag is set, designating the maneuver as a main engine, MOI, or thruster burn. During the burn, the spacecraft attitude is controlled to within a pre-selected set of position and rate error thresholds. Violation of these thresholds will cause the maneuver to abort to the Sun Comm Power attitude control state, which provides autonomous payload sun avoidance protection. An option exists in the block to perform a pitchover maneuver, in which a selected attitude rate about a selected axis is commanded.

At the desired burn start time, the flight software is commanded from the ISH attitude control mode to the maneuver submode of ISH.

For main engine burns including MOI, the flight software maneuver task first commands the thrusters in an off-pulse mode for normally 20 seconds (selectable via General Memory Load) to effect an ullage burn. The ullage burn is performed to minimize the transients associated with propellant sloshing when the main engine is fired. Upon completion of the ullage burn, the maneuver task fires the main engine to initiate the delta V burn. The appropriate thrusters are fired in an on-pulse mode to maintain the spacecraft within the pre-selected position and rate thresholds.

For thruster delta V maneuvers, the flight software maneuver task fires the selected thrusters in an off-pulse mode to initiate the burn. The other thrusters are fired in an on-pulse mode to maintain the spacecraft within the pre-selected position and rate thresholds.

Ten seconds after main engine burn start, the main engine injector heaters are turned off and disabled.

The reaction wheels are maintained in tach hold at their initial or ground loaded speeds throughout the duration of the burn. The maneuver task will terminate the maneuver when either the desired delta V has been achieved, the backup maximum burn cut off time occurs, or one of the maneuver abort criteria is met. Upon maneuver termination, the main engine and thrusters are autonomously disarmed and disabled, the IMU commanded back to the all gyro format and attitude control is transitioned back to the ISH mode, with reaction wheel control resumed. Flight software then restores the ullage burn flag status to “False” upon completion of the burn.

After the backup maximum maneuver duration time, the block (as implemented by on-board scripts) resumes execution. The frozen gyro check is disabled. The spacecraft is then commanded back to the ANS attitude control mode, in which the spacecraft is slewed to align the spacecraft $+X_b$ axis along the Earth line (as determined from the on-board planetary ephemeris) and upon target acquisition, rotated about the X axis at 0.01 rpm. During the slew to ANS, the solar arrays are commanded back to their cruise positions. If the skew wheel was powered on as part of the tach hold option, it is powered back off 10 minutes after the command to go to ANS.

After allowing sufficient time for the main engine to cool, redundancy management for the main engine DTC#7 heater is re-enabled.

4.4.2 Constraints

1. The required flight software maneuver parameters (e.g., delta V, maximum maneuver duration, target quaternion), must be loaded via the MANLOAD block or an alternative ground procedure prior to execution of this MNVR block. The maximum burn duration must match the equivalent parameter in the MANLOAD block.

2. The block SSRMGR shall be executed at a desired time prior to the execution of MNVR, to record 2 kbps engineering data throughout the maneuver activity. The EDF shall be in engineering mode. The XSU shall be configured to route EDF 2 kbps engineering telemetry to the SSR.

3. If the TES is powered on prior to a maneuver, the block TES shall first be executed to safe the instrument.

4. The +Yb and -Yb solar array gimbal drives must be powered on and their redundancy management enabled prior to execution of this block. For main engine burns, the gimbals must be positioned against their hard stops. For thruster burns, the panels must be oriented to provide proper center of mass control; positioning against the hard stops provides this control and is therefore selected for both main engine and thruster burns. The soft stops must be disabled outside this block in order to allow the panels to reach the hard stops.

5. For main engine burns, latch valves LV4 and LV5 are opened by this block to ensure propellant flow to the engine valves. LV4 and LV5 are not closed by this block after the burn. LV2 and/or LV3 (depending on which string[s] are selected for the burn) must also be open to allow hydrazine flow to the thrusters for attitude control during the main engine burn. LV2 and LV3 are not opened by this block.

6. For thruster burns, latch valves LV2 and/or LV3 (depending on which string[s] are selected for the burn) must be open to allow hydrazine flow to the thrusters. LV2 and LV3 are not opened by this block.

7. For main engine burns, the delta V contribution of the ullage burn must be accounted for in computing the parameter MAX_DUR in this block and the MANLOAD block, as well as the parameter DELTA_V in the MANLOAD block.

8. The parameter SLEW_DUR must be set greater than or equal to the greatest of the four times required for: a) the solar panels to move to their desired positions before the burn, b) the spacecraft to turn to the desired attitude before the burn, c) the solar panels to move to their desired positions after the burn, and d) the spacecraft to turn to the desired attitude after the burn.

9. The IMU shall be in high rate mode.

10. The block assumes the Actuator Select Flag is set to reaction wheels prior to execution of this block. The block has an option to maintain wheel speeds at their current values during maneuver execution or to set them to a ground specified set of wheel speeds.

11. In the event of a hydrazine half string latchout due to a leaking thruster, the thruster configuration flag shall be set designating which string is to be used, prior to execution of this block. The thruster side selection in the block should be consistent with the flight software knowledge of which side is enabled (String Utilization Flag).

12. An appropriate maneuver abort Contingency Mode cleanup script must be on-board and enabled prior to execution of this block.

13. For MOI, the following additional constraints apply:
    a) Safe Mode shall be disabled prior to MOI. The determination of the actual time to disable safe mode will depend upon the ground's ability to recognize that the spacecraft is in safe mode, to determine and remedy the cause of entry, and initiate the recovery process to configure the spacecraft for MOI, while minimizing the amount of time the spacecraft is without this fault protection. For information, a value of 10 days was used for Mars Observer.
    b) Contingency Mode shall be disarmed prior to MOI. The contingency mode initiated MOI configuration script shall be loaded with the MOI sequence. This script shall contain the command to transition the spacecraft to the "sun star init" attitude control state, in order to allow inertial reference to be autonomously reestablished prior to the execution of the MOI

block. Contingency mode shall be disabled at least 4 hours prior to the start of the MOI burn. Four hours is the maximum time required for inertial reference to be reestablished in the "sun star init" attitude control state.

c) The sun-monitor-ephemeris attitude check and gyro short recovery shall both be disabled at least 4 hours prior to MOI in order to allow sufficient time to recover inertial reference in the event of an attitude or gyro short anomaly.

d) All scripts in the MOI sequence shall have their activation control bits set to ensure sequence execution: the proceed on error bit, the late execution bit, and the contingency mode bit shall be enabled.

e) The MOI sequence shall be enabled for execution in contingency mode.

f) Prior to execution of MOI, the PRESSURE block shall be executed, if necessary, to un-isolate and pressurize the oxidizer tank to ~260 psi.

Parameter Table (MNVR)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, prior to initiation of the burn. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes.
1.2	INJCTR_DUR	INPUT	DUR	hh:mm:ss	00:15:00 -01:15:00	01:00:00	Desired warmup time of the main engine injector heaters, before initiation of the burn. Normally set to 60 minutes.
1.3	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:05:00 - 00:20:00	00:10:30	Maximum expected slew time to turn the spacecraft to the maneuver attitude.
1.4	REA_SELECT	INPUT	CHAR	N/A	BOTH ODD EVEN	BOTH	Selects desired REA thruster configuration for control during the burn. Normally set to BOTH, to utilize both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be used.
1.5	PITCH_OVER	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to designate the maneuver to be executed as a pitchover maneuver. The pitch rate and vector are selected by parameters 2.1 and 2.2.
1.6	BURN_TYPE	INPUT	CHAR	N/A	MAIN_ENG THRUSTERS MOI	THRUSTERS	Parameter used to select main engine bipropellant burn or thruster monopropellant burn. Selecting ‘MOI’ invokes special fault protection routines designed to ensure the burn continues to completion.
1.7	SAP_AZ_BURN	INPUT	REAL	radians	-3.6652 to 2.6180	-0.5236	Parameter used to set +Y outer gimbal position for the burn. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft -Z axis.
1.8	SAP_EL_BURN	INPUT	REAL	radians	-3.6652 to 2.6180	0.0	Parameter used to set +Y inner gimbal position for the burn. Default value is set to 0 deg, facing the cells aft toward the spacecraft -Z axis.
1.9	SAM_AZ_BURN	INPUT	REAL	radians	-2.6180 to 3.6652	-0.5236	Parameter used to set -Y outer gimbal position for the burn. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft -Z axis.

Parameter Table (MNVR)

No	Name	Source	Type	Units	Range	Default	Definition
1.10	SAM_EL_BURN	INPUT	REAL	radians	-2.6180 to 3.6652	0.0	Parameter used to set -Y inner gimbal position for the burn. Default value is set to 0 deg, facing the cells aft toward the spacecraft -Z axis.
1.11	SAP_AZ_ANS	INPUT	REAL	radians	-3.6652 to 2.6180	-0.5236	Parameter used to set +Y outer gimbal position for the post-burn ANS attitude. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft +X axis.
1.12	SAP_EL_ANS	INPUT	REAL	radians	-3.6652 to 2.6180	-1.5708	Parameter used to set +Y inner gimbal position for the post-burn ANS attitude. Default value is set to -90 deg, facing the cells toward the spacecraft +X axis.
1.13	SAM_AZ_ANS	INPUT	REAL	radians	-2.6180 to 3.6652	-0.5236	Parameter used to set -Y outer gimbal position for the post-burn ANS attitude. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft +X axis.
1.14	SAM_EL_ANS	INPUT	REAL	radians	-2.6180 to 3.6652	1.5708	Parameter used to set -Y inner gimbal position for the post-burn ANS attitude. Default value is set to +90 deg, facing the cells toward the spacecraft +X axis.
1.15	REDMAN_DUR	INPUT	DUR	hh:mm:ss	00:00:00 -02:00:00	01:00:00	Period of time during which REDMAN is disabled to prevent inadvertent swap to redundant main engine heater due to high soakback temperatures. Greater than or equal to maximum burn duration plus cooldown time.
1.16	ULLAGE_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 00:00:40	00:00:20	Ullage burn duration. Must match onboard value of “ullage’burn’duration” loaded via General Memory Load.
1.17	TACH_HOLD	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to load ground defined tach hold wheel speeds prior to the maneuver, rather than just allowing the maneuver task to hold the wheels at their speeds upon initiation of the burn. This option is primarily used for MOI, when the under pressure fault protection logic is enabled, to protect the wheels from damage in the event of an autonomous pyro firing.

Parameter Table (MNVR)

No	Name	Source	Type	Units	Range	Default	Definition
1.18	S_RWA	INPUT	CHAR	N/A	'OFF' 'ON'	'OFF'	Parameter used to determine whether the skew RWA is currently powered off, and thus not being used for attitude control. This will ensure that the skew RWA is turned on during the block execution for safing during the maneuver in the event of an autonomous pyro firing due to a tank under pressure situation. Set if Parameter 1.17 TACH_HOLD is set to TRUE. If an orthogonal RWA had failed previously, the skew wheel will already be powered on and its state will not be changed in this block. If an orthogonal RWA had previously behaved erratically and was shut off, but it is still desired to turn it on to safe it for the maneuver in the event of an autonomous pyro firing, then it must be powered on and off externally to this block.
1.19	X_WHL_SPD_INIT	INPUT	INT	wcounts (1 wcount = 5 rpm)	-600 to 600	+40	Parameter used to set desired X RWA tach hold speeds to be maintained during the maneuver. Set if Parameter 1.17 TACH_HOLD is set to TRUE.
1.20	Y_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	-40	Parameter used to set desired Y RWA tach hold speed to be maintained during the maneuver. Set if Parameter 1.17 TACH_HOLD is set to TRUE.
1.21	Z_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+40	Parameter used to set desired Z RWA tach hold speed to be maintained during the maneuver. Set if Parameter 1.17 TACH_HOLD is set to TRUE.
1.22	S_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+69	Parameter used to set desired skew RWA tach hold speed to be maintained during the maneuver. Set if Parameter 1.17 TACH_HOLD is set to TRUE.

Parameter Table (MNVR)

No	Name	Source	Type	Units	Range	Default	Definition
2.0	BURN_START	PDB	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Predicted start time of the thruster burn or the ullage burn preceding the main engine burn. The ullage burn is performed by firing the appropriate hydrazine thrusters for a brief period before the firing of the main engine, in order to reduce the transients associated with propellant sloshing when the main engine is fired. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
2.1	PITCH_RATE	PDB	REAL	rad/sec	N/A	N/A	The desired pitch rate for pitchover maneuvers, if Parameter No. 1.5 PITCH_OVER is set to TRUE.
2.2	PITCH_VEC	PDB	REAL(3)	N/A	N/A	N/A	The desired pitch vector for pitchover maneuvers, if Parameter No. 1.5 PITCH_OVER is set to TRUE.
2.3	MAX_DUR	PDB	DUR	hh:mm:ss	N/A	N/A	Maximum burn duration. This parameter must match the value loaded via the MANLOAD block. If the accumulated burn time equals this time and the desired delta V has not been achieved, the maneuver task will terminate the burn. The value supplied for this parameter must account for the ullage burn delta V contribution for main engine burns.
3.0	BACKUP_DUR	CALC	DUR	hh:mm:ss	N/A	N/A	The time from initiation of the burn for the block to resume control and command the spacecraft back to its nominal configuration. The value of BACKUP_DUR shall be 5 seconds greater than the value of the flight software backup maximum burn time (Parameter 2.3 MAX_DUR), to allow the maneuver task time to complete post-burn activities. BACKUP_DUR = MAX_DUR + 00:00:05
3.1	REA_ODD	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the odd string of thrusters (1,3,5,7,9,12) is to be enabled and armed for the maneuver. Calculated from the REA thruster configuration selection, Parameter No. 1.4, REA_SELECT. IF (REA_SELECT = BOTH OR ODD) THEN REA_ODD = TRUE

Parameter Table (MNVR)

No	Name	Source	Type	Units	Range	Default	Definition
3.2	REA_EVEN	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the even string of thrusters (2,4,6,8,10,11) is to be enabled and armed for the maneuver. Calculated from the REA thruster configuration selection, Parameter No. 1.4, REA_SELECT. IF (REA_SELECT = BOTH OR EVEN) THEN REA_EVEN = TRUE

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of MNVR block execution.
2.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), normally 30 min prior to the burn.
2.0.1	enable REA & turn on catbed htr no 1		PRC01E	T = BURN_START - CATBED_DUR - 00:00:01	
2.0.2	enable REA & turn on catbed htr no 3		PRC03E		
2.0.3	enable REA & turn on catbed htr no 5		PRC05E		
2.0.4	enable REA & turn on catbed htr no 7		PRC07E		
2.0.5	enable REA & turn on catbed htr no 9		PRC09E		
2.0.6	enable REA & turn on catbed htr no 12		PRC12E		
2.1	END IF		TEST		
2.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) normally 30 min prior to the burn.
2.2.1	enable REA & turn on catbed htr no 2		PRC02E	T = BURN_START - CATBED_DUR	
2.2.2	enable REA & turn on catbed htr no 4		PRC04E		
2.2.3	enable REA & turn on catbed htr no 6		PRC06E		
2.2.4	enable REA & turn on catbed htr no 8		PRC08E		
2.2.5	enable REA & turn on catbed htr no 10		PRC10E		
2.2.6	enable REA & turn on catbed htr no 11		PRC11E		
2.3	END IF		TEST		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0	IF (BURN_TYPE = MAIN_ENG .OR. BURN_TYPE = MOI) THEN		TEST		Enable and turn on the main engine injector heater (both primary and secondary), normally 60 minutes prior to the burn.
3.0.1	enable main engine injector heater pri		PRMHPE	T = BURN_START - INJCTR_DUR - 00:00:01	
3.0.2	enable main engine injector heater sec		PRMHSE		
3.0.3	turn on main engine injector heater pri		PRMHPN	T = BURN_START - INJCTR_DUR	
3.0.4	turn on main engine injector heater sec		PRMHSN		
3.1	ENDIF		TEST		
3.2	IF (BURN_TYPE = MOI) THEN		TEST		
3.2.1	set aacs inertial reference established flag to TRUE		SADINR	T = BURN_START - SLEW_DUR - 00:02:01	In the anomalous event that inertial reference has not been exactly established prior to MOI, then IRE shall be forced equal to TRUE to ensure that the turn to the burn attitude will still occur.
3.3	ENDIF		TEST		
4.0	set attitude control state to inertial slew hold (ISH)		SAGISH	T = BURN_START - SLEW_DUR - 00:02:00	Command the spacecraft to the ISH attitude control state. Attitude control software will slew to the desired burn attitude, using the reaction wheels. In ISH mode, nominal momentum unloading is disabled, although emergency unloading is available. Additionally in ISH mode, star processing is disabled. The ISH control parameters for the burn (pitch axis and target quaternion) are loaded in the MANLOAD block.

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_BURN inboard gimbal angle = SAP_EL_BURN		SALPTA	T= BURN_START - SLEW_DUR - 00:01:00	Load the desired maneuver gimbal target angles for the inboard and outboard gimbals of the +Yb and -Yb mounted solar arrays. For main engine burns, the solar arrays are positioned with the front side of the arrays canted 30° towards the -Z axis (parameter default). This orientation will hold the arrays against the gimbal hard stops as the spacecraft accelerates during the burn. For thruster burns, there is no requirement to position the solar arrays against the hard stops for load reasons, but that position satisfies center-of-mass constraints, so the panels should normally be positioned against the hard stops for all maneuvers.
5.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_BURN inboard gimbal angle = SAM_EL_BURN		SALMTA	T= BURN_START - SLEW_DUR - 00:00:59	The manual gimbal drive rate command is referenced from an absolute zero reference point, defined to be the XY gimbal plane.
5.2	enable +Yb solar array manual gimbal drive rate control		SAPRCE	T= BURN_START - SLEW_DUR - 00:00:58	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the inboard and outboard gimbals will move to the target angles loaded in Events 5.0 and 5.1 at the times the target angles are loaded.
5.3	enable -Yb solar array manual gimbal drive rate control		SAMRCE		
6.0	switch IMU to accelerometer output format		SRACCF	T= BURN_START - 00:02:01	The IMU will be switched to the accelerometer output format prior to the start of the maneuver. The IMU must be in this mode in order for the flight software maneuver task to process accelerometer telemetry in order to determine delta V accumulation and the maneuver cutoff time.

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.1	enable frozen gyro check		SAFIME	T = BURN_START - 00:02:01	While the IMU is in the accelerometer output format, in which the 6 gyro co-channel compare ability is not available, a frozen gyro could be mission critical during a biprop maneuver. Thus the frozen gyro check will be enabled so that the flight s/w can select the backup gyro axis if the gyro output remains identical for a selected number of consecutive cycles.
6.2	perform accelerometer null bias measurement		SMMACB	T = BURN_START - 00:02:00	The accelerometer bias measurement is initiated to measure the accelerometer output for a desired time (nominally 100 sec) during a quiescent period prior to the start of the maneuver, in order to determine the accelerometer biases.
7.0	IF (BURN_TYPE = MAIN_ENG .OR. BURN_TYPE = MOI) THEN		TEST		
7.0.1	IF (TACH_HOLD = TRUE) THEN		TEST		For main engine burns, an option exists to manually set the reaction wheel speeds to be held during the maneuver when control is switched to thrusters. This is done primarily to protect the wheels from possible pyro shock damage as a result of autonomous fault protection pyro firings due to tank over or under pressure fault conditions.

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0.1.1	IF (S_RWA = OFF) THEN		TEST		
7.0.1.1.1	turn on skew RWA		ARWASN	T = BURN_START - 00:01:10	Only three RWAs (nominally the three orthogonal RWAs) are powered on for attitude control. If the skew wheel is powered off, it could potentially be damaged if it is not powered on and spinning during potential autonomous pyro firing events. Thus it is turned on to safe it for the pyro firing event. If the skew wheel is already on, one of the orthogonal wheels has probably failed and should not be turned on. If one of the orthogonal wheels had been turned off because it exhibited undesirable behavior but is worth preserving, it should be turned on by command outside this block.
7.0.1.2	END IF				
7.0.1.3	set tach hold wheel speeds X_WHL_SPD_INIT Y_WHL_SPD_INIT Z_WHL_SPD_INIT S_WHL_SPD_INIT		SALFWS	T = BURN_START - 00:01:01	Load the desired wheel speeds to be maintained during the burn. If the current wheel speed is greater than WHL_SPD_INIT, the current speed is unchanged.
7.0.1.4	enable ground tach hold		SAATHE	T = BURN_START - 00:01:00	Enable the ground tach hold option for main engine maneuvers.
7.0.2	ELSE		TEST		
7.0.2.1	enable tach hold init		SAATHX	T = BURN_START - 00:01:00	Enable tach hold init option for main engine maneuvers. Wheels will be maintained at current speeds upon initiation of the burn.
7.0.3	END IF		TEST		
7.0.4	disable main engine heater REDMAN		SHMVDX	T = BURN_START - 00:00:15	Disable redundancy management for the engine DTC#7 heaters since heat soakback from the engine would cause REDMAN to believe that the primary heater had failed on, triggering a swap to the redundant heater.

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0.5	enable main engine valve pri		PRMEPE	T= BURN_START - 00:00:14	
7.0.6	enable main engine valve sec		PRMESE		
7.0.7	enable latch valves 4 and 5		PRL04E PRL05E	T= BURN_START - 00:00:13	Enable, arm and open the main engine bipropellant latch valves, in the event the ground or autonomous flight software had previously closed the latch valves due to a leaky main engine valve.
7.0.8	arm latch valves 4 and 5		PRL04A PRL05A	T= BURN_START - 00:00:12	
7.0.9	open latch valve 4		PRL04O	T= BURN_START - 00:00:09	
7.0.10	open latch valve 5		PRL05O		
7.0.11	disarm latch valves 4 and 5		PRL04D PRL05D	T= BURN_START - 00:00:06	
7.0.12	disable latch valves 4 and 5		PRL04X PRL05X	T= BURN_START - 00:00:05	
7.1	ENDIF		TEST		
8.0	IF (REA_ODD) THEN		TEST		Re-enable the selected thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off and the thrusters disarmed & disabled.
8.0.1	enable REA & catbed heater no 1		PRC01E	T= BURN_START - 00:00:04	
8.0.2	enable REA & catbed heater no 3		PRC03E		
8.0.3	enable REA & catbed heater no 5		PRC05E		
8.0.4	enable REA & catbed heater no 7		PRC07E		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.0.5	enable REA & catbed heater no 9		PRC09E	T = BURN_START - 00:00:04	
8.0.6	enable REA & catbed heater no 12		PRC12E		
8.0.7	arm REAs 1,3,5,7,9,12		PRTHOA	T = BURN_START - 00:00:02	
8.1	END IF		TEST		
8.2	IF (REA_EVEN) THEN		TEST		
8.2.1	enable REA & catbed heater no 2		PRC02E	T = BURN_START - 00:00:03	
8.2.2	enable REA & catbed heater no 4		PRC04E		
8.2.3	enable REA & catbed heater no 6		PRC06E		
8.2.4	enable REA & catbed heater no 8		PRC08E		
8.2.5	enable REA & catbed heater no 10		PRC10E		
8.2.6	enable REA & catbed heater no 11		PRC11E		
8.2.7	arm REAs 2,4,6,8,10,11		PRTHEA	T = BURN_START - 00:00:02	
8.3	END IF		TEST		
9.0	IF (BURN_TYPE = MAIN_ENG) THEN		TEST		Select main engine burn for flight software maneuver task.
9.0.1	set maneuver configuration flag for main engine burn		SMMEDV	T = BURN_START - 00:00:01	
9.0.2	enable ullage burn		SMUBPR		Enable ullage burn on even and odd thrusters.
9.1	ENDIF		TEST		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
10.0	IF (BURN_TYPE = MOI) THEN		TEST		Select MOI burn for flight software maneuver task.
10.0.1	set maneuver configuration flag for Mars orbit insertion burn		SMMEMO	T = BURN_START - 00:00:01	
10.0.3	enable ullage burn		SMUBPR	T = BURN_START - 00:00:01	Enable ullage burn on even and odd thrusters.
10.1	ENDIF		TEST		
11.0	IF (BURN_TYPE = THRUSTERS) THEN		TEST		Select thruster burn for flight software maneuver task.
11.0.1	set maneuver configuration flag for thruster burn		SMTHDV	T = BURN_START - 00:00:01	
11.1	ENDIF		TEST		
12.0	IF (PITCH_OVER) THEN		TEST		If the maneuver to be performed is a pitchover maneuver, the desired pitch rate must be loaded at the maneuver start time.
12.1.1	load ISH pitch rate and vector PITCH_RATE PITCH_VEC		SALICP	T=BURN_START	Load the control parameters for the pitchover.
12.2	END IF		TEST		
13.0	set AACS control state to maneuver		SMEXEC	T=BURN_START	The flight software will be commanded to the maneuver control state, to begin the maneuver.
13.1	set nominal actuator select flag to thruster control		SAASFT		Attitude control is maintained by mass expulsion during maneuvers.
13.2	set contingency actuator select flag to thruster control		SAACMT		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
13.3	*arm thrusters* *arm main engine if applicable*		*FSW*	*T=BURN_START*	*The maneuver task autonomously arms the thrusters and, if appropriate, the main engine.*
13.4	*if main engine delta V, perform ullage burn using RCS thrusters*		*FSW*		*For main engine maneuvers only, upon receipt of the execute maneuver command, the maneuver task first commands a (normally) 20 second ullage burn using the RCS thrusters, to reduce the transients associated with propellant orientation when the main engine is fired. The task uses the thruster string(s) designated by the String Utilization Flag.*
13.5	*fire main engine and/or thrusters*		*FSW*	*T=BURN_START* *+ ULLAGE_DUR*	*Upon completion of the ullage burn, the flight software will begin firing the main engine to initiate the delta V burn. In the case of a thruster burn, the ullage burn duration is zero. During the maneuver, the flight software will control the attitude of the s/c to the commanded inertial attitude (and rate for pitch over maneuvers) with the thrusters. RWA speed will be controlled to the value previously set.*
13.6	IF (BURN_TYPE = MAIN_ENG .OR. BURN_TYPE = MOI) THEN		TEST		Turn off and disable main engine injector heater ten seconds after the completion of the ullage burn.
13.6.1	turn off main engine injector heater pri		PRMHPF	T = BURN_START + ULLAGE_DUR + 00:00:10	
13.6.2	turn off main engine injector heater sec		PRMHSF		
13.6.3	disable main engine injector heater pri		PRMHPX	T = BURN_START + ULLAGE_DUR + 00:00:10	
13.6.4	disable main engine injector heater sec		PRMHSX		
13.7	ENDIF		TEST		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
13.8	*end maneuver* *close engine valves* *disarm main engine* *disable main engine* *switch IMU to all gyro format*		*FSW*	*Performance*	*The flight software maneuver task will autonomously end the maneuver when either the desired delta V has been achieved, the backup maximum burn cutoff time occurs, or one of the maneuver abort criteria is met. The flight software will abort the maneuver if the unfiltered indicated body rates or accelerations exceed allowable values or the s/c attitude is greater than a selected cone angle (nominally 30°) from the desired burn attitude for three consecutive 10 Hz cycles or the sun ephemeris monitor test indicates an excessive error between the predicted and measured sun angle.* *The flight software will autonomously transition to the inertial slew hold (non maneuver) attitude control state. Note that if the maneuver executed was a pitchover maneuver, then the specified pitch rate will be continued under thruster control, until the s/c is commanded back to array normal spin.* *The maneuver task autonomously disables and disarms the main engine upon completion of the burn and switches the IMU back to all gyro format, and sets the ullage burn flag to 'False'.*
14.0	disable frozen gyro check		SAFIMX	T= BURN_START + BACKUP_DUR	The frozen gyro check is disabled upon completion of the maneuver.
15.0	set nominal actuator select flag to RWA control		SAASFW	T= BURN_START + BACKUP_DUR + 00:00:30	Return attitude control to reaction wheels after the maneuver. Thirty seconds are allocated for settling time.
15.1	set contingency actuator select flag to RWA control		SAACMW		

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
16.0	disarm REAs 1,3,5,7,9,12		PRTHOD	T = BURN_START + BACKUP_DUR + 00:00:31	Disarm thrusters after switching to reaction wheel control.
16.1	disarm REAs 2,4,6,8,10,11		PRTHED		
16.2	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T = BURN_START + BACKUP_DUR + 00:00:32	Disable thrusters after switching to reaction wheel control.
16.3	disable REAs & catbed heaters no 2,4,6		PRCTBX		
16.4	disable REAs & catbed heaters no 7,9,12		PRCTCX		
16.5	disable REAs & catbed heaters no 8,10,11		PRCTDX		
17.0	set AACS control state to array normal spin (ANS)		SAGANS	T = BURN_START + BACKUP_DUR + 00:00:34	The flight software will begin the slew back to the array normal spin attitude and initiate the desired rotation rate.
18.0	IF (PITCH_OVER) THEN		TEST		If the maneuver was a pitchover maneuver, the desired pitch rate is returned to zero.
18.0.1	load ISH pitch rate Pitch Rate = 0.0		SALISR	T = BURN_START + BACKUP_DUR + 00:00:35	
18.1	END IF		TEST		
19.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_ANS inboard gimbal angle = SAP_EL_ANS		SALPTA	T = BURN_START + BACKUP_DUR + 00:01:34	Load the desired ANS gimbal target angles for the inboard and outboard gimbals of the $+Y_b$ and $-Y_b$ mounted solar arrays.
19.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_ANS inboard gimbal angle = SAM_EL_ANS		SALMTA	T = BURN_START + BACKUP_DUR + 00:01:35	The manual gimbal drive rate command is referenced from an absolute zero reference point, defined to be the XY gimbal plane.

Event Table (MNVR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
20.0	IF (TACH_HOLD = TRUE) THEN		TEST		
20.0.1	IF (S_RWA = OFF) THEN		TEST		If the skew wheel was powered on for this block, it is powered back off here. If the skew wheel was already on, it is left on. If one of the orthogonal wheels was turned on by realtime command outside this block because it exhibited undesirable behavior but was worth preserving, it should be turned back off by command outside this block.
20.0.1.1	turn off skew RWA		ARWASF	T = BURN_START + BACKUP_DUR + 00:10:34	Allow 10 minutes from the time ANS was re-enabled, before turning back off the RWA which is not being used for attitude control. This will ensure that the telemetry from that wheel will be processed by the AACS software for health and status as the wheel spins down to 0 rpm.
20.0.1.2	use wheels XYZ		SRUXYZ	T = BURN_START + BACKUP_DUR + 00:10:35	After turning off the skew RWA, re-command redundancy management to use the XYZ wheels. This will prevent unnecessary switching of the CIU bus in the event one of the three orthogonal wheels were to fail during the pyro firing event. Thus for example, if the Y wheel were to fail and then the skew wheel was turned back off after the sequence, then REDMAN would believe there were two failed wheels and would switch buses.
20.0.2	END IF		TEST		
20.1	END IF		TEST		
21.0	IF (BURN_TYPE = MAIN_ENG .OR. BURN_TYPE = MOI) THEN		TEST		
21.0.1	enable main engine heater REDMAN		SHMVDE	T = BURN_START + REDMAN_DUR	Re-enable redundancy management for the engine DTC#7 heaters after engine has cooled.
21.1	ENDIF		TEST		
22.0	END BLOCK		STATE		Completion of MNVR block execution.

State Table (MNVR)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Control State	array normal spin	inertial slew hold » maneuver » inertial slew hold	array normal spin
	IMU rate mode	high rate mode	high rate mode	high rate mode
	IMU output format	all gyro	accelerometer	all gyro
	IMU frozen gyro check	disabled	enabled	disabled
	Reaction wheels	control mode	tach hold	control mode
	Solar array positions	array normal spin	maneuver	array normal spin
	Solar array manual gimbal drive rate control	disabled	enabled	disabled
Propulsion				
	Main engine	disabled and disarmed	For main engine maneuvers: enabled, armed, fired	disabled and disarmed
	Main engine injector heaters	disabled and off	For main engine maneuvers: enabled and on	disabled and off
	Thrusters[1]	disabled and disarmed	enabled, armed, fired	disabled and disarmed
	Thruster catalyst bed heaters[1]	off	on	off
	Latch valves 4 and 5	disabled, disarmed, closed	For main engine maneuvers: enabled, armed, open	disabled, disarmed, closed
Thermal				
	Redundancy management for engine heater DTC#7	enabled	disabled	enabled

[1] The actual thrusters which will be used for the maneuver depend on the selection of odd, even, or both strings.

State Table (MNVR)

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4.5 AEROBRAKE - Aerobrake Drag Pass Block

4.5.1 Block Description

This block is used to command the spacecraft to the proper orientation and configuration for entry into and out of the Mars atmosphere each orbit during the aerobraking portion of the orbit insertion phase.

All events in the block are timed relative to the start of the drag pass, with a delay segment added to each end of the drag pass as margin to protect against timing errors due to navigation uncertainties, atmospheric blooming and missed periapsis altitude adjustment maneuvers.

The first event peformed by the block is to begin recording the high rate 2000 bps engineering telemetry 35 minutes prior to the start of the drag pass. An option exists in the block to not record and/or playback the drag pass events. Recording and playback can also be independently managed using the SSRMGR block.

The next event in the block is to warmup the catbed heaters of the 4.4 N thrusters to be used for attitude control during the drag pass. Depending on the configuration of the propulsion system, the block has an option to use all twelve of the thrusters or in the event of a half-side latch out, either the odd or even string of thrusters. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used.

Several minutes prior to the start of the turn to the aerobraking initial drag attitude, the batteries are disconnected from the 0.18 A alternate trickle charger, the BCR charge rate set to 7.5 A and the batteries are reconnected to the BCR. This will allow the batteries to immediately and quickly recharge upon reacquisition of ANS after the drag pass. The battery_BCR configuration is optional in the block and is intended to be used while the orbit period is greater than 2 hours. During the end-game, the batteries will always remain connected to the BCR.

Immediately prior to the start of the turn to the aerobraking drag attitude, the TWTA is turned off due to power limitations. The block has an option to power off the MOT Exciter during the drag pass. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired to power off the Exciter during the drag pass when communications are unavailable. For larger orbits, unnecessary Exciter power cycling is undesirable. Note that current flight software turns off the Exciter when the TWTA beam is turned off. Until the (approved) change to disconnect ‘Exciter off’ from ‘TWTA beam off’ is incorporated, the Exciter will be powered off for the drag pass regardless of this option.

The CSA/Backup attitude control mode is normally used to acquire and maintain the required spacecraft nadir attitude for aerobraking, where the spacecraft $-X_b$ axis is maintained in the nadir direction and the $-Z_b$ axis along the orbit velocity vector. The CSA/Backup mode requires that a Mars inertial reference frame ephemeris be pre-loaded and activated prior to entry, and that the mapping ephemeris logic is enabled. The CSA/Backup mode attitude control errors are derived from the StarEx generated inertial-to-body quaternion and the Mars orbit ephemeris derived orbit angles. Unlike the normal mapping CSA/Backup mode, star processing, HGA Earth tracking and SA sun tracking will all be disabled.

A major constraint associated with the CSA/Backup attitude control mode is that autonomous payload sun avoidance protection is not available. Therefore prior to commanding to the CSA/Backup mode, the block first commands the spacecraft to the ISH attitude control mode to slew the spacecraft to an initial inertial attitude, utilizing the autonomous sun avoidance protection available in ISH mode, from which CSA/Backup mode can be safely initiated.

An option exists in the block to bypass the CSA/Backup mode and instead use the ISH attitude control mode to acquire and hold an inertial attitude through the drag pass. A third option is also available to utilize the ISH slew submode to control to the desired inertial target, while rotating about a selected vector at a selected rate, in order to simulate a nadir orientation throughout the drag pass. The slew vector should be set to the spacecraft $+Y_b$ axis, with the slew rate set to approximate the orbital rate for the current orbital period.

Immediately upon commanding to ISH mode to initiate the turn to the CSA_BU initial attitude, the sun_monitor_ephemeris check is disabled and the sun angle error timer set to 1 hour for the duration of the drag pass. This is to prohibit an undesired entry into contingency mode due to a false attitude check or REDMAN swapping of the SSA to side B due to possible albedo from the planet causing the SSA to mistake Mars for the Sun.

Once the spacecraft has begun the slew to the aerobraking attitude, the solar arrays are oriented to their required positions for the drag pass. The original pre-launch design had the solar arrays canted 30° towards the spacecraft $+Z_b$ axis in order to provide aerodynamic stability (places the center-of-pressure aft of the center-of-gravity) while ensuring sufficient drag levels to achieve the desired velocity changes to reach the mapping orbit. Additionally the back side of the arrays were positioned into the incoming flow to shield the active cell sides. The failure of the SAM to properly deploy after launch (20.5 ° short of the latched position) requires SAM to be orientedwith the cell sides forward into the drag flow, to keep the drag force against the hinge obstruction in order to prevent the panel from folding up during the drag pass.The solar arrays are each commanded in the manual rate mode to an absolute azimuth and elevation gimbal position. Relative to the arrays' cruise positions, each arrays' elevation gimbal will be rotated 90°.

Twenty seconds prior to the start of the drag pass, the IMU is commanded to the accelerometer output format. The accelerometer data provides an important measurement for reconstructing the atmospheric density throughout the pass and is recorded on the SSRs with the rest of the high rate engineering data for playback after the pass. Setting the IMU to accelerometer output format disables the gyro co-channel compare capability, so the IMU frozen gyro check is also enabled to allow the flight software to select backup gyro axis data if the gyro output remains unchanged for a selected number of consecutive cycles.

As a consequence of having to orient SAM with the cell sides into the drag flow, the array is not against the hard stop during the drag pass as originally designed. Modifications to the flight software SA gimbal articulation logic have been made to support a SAM GDE “powered-hold” capability. This “stop” or powered-hold mode provides sufficient holding torque against the aerodynamic force to prevent the panel from backdriving during the drag pass.

Six and a half minutes prior to periapsis at an altitude of approximately 300 km, the ER high voltage shall be turned off in order to prevent possible damage due to arcing at altitudes less than 150 km. At the same time, the ER is also commanded into its aerobraking mode during the period of time that the high voltage is turned off.

Three seconds prior to the start of the pre-drag delay segment, the 4.4 N thrusters to be used for attitude control during the pass are re-enabled and their catbed heaters turned back on, in the event an emergency momentum unloading was autonomously performed during the slew to the aerobraking attitude, resulting in the thrusters being disarmed and disabled after the event by the flight software. One second prior to the pre-drag delay segment, the thrusters are armed. At the beginning of the pre-drag delay segment, active control is switched from RWAs to thrusters. The default aerobraking thruster gains allow a wider deadband (15 degrees) to minimize hydrazine consumption, while maintaining adequate control authority during the drag pass. The RWAs are maintained in tach hold mode at a ground specified speed throughout the drag pass. At the predicted end of drag (typically less than 10% of peak dynamic pressure), the "end of drag pass" indicator is set, causing a switch to a post drag thruster gain set, in preparation for switching back to RWA control. RWA control is resumed after the post drag delay segment, normally set to about five minutes, to allow the thrusters adequate time to control to the tighter gains. Also at this time the thrusters are disarmed and disabled, their catbed heaters turned off, and the IMU is set back to the all-gyro output format with the frozen gyro check disabled.

The block maintains wheel speeds at their current values as the drag pass is entered. The wheel speeds are then set to a preset valueapproximately at the time of peak aerodynamic force (when spindown effects will be minimum) to obtain a "free" momentum unload. This approach is expected to reduce or eliminate the chances of experiencing momentum unloading during the remainder of the orbit.

The spacecraft is next commanded back to the ANS attitude control mode, in which the spacecraft will slew to align the spacecraft $+X_b$ axis along the Earth line and upon target acquisition, rotate the spacecraft about the X axis at 0.01 rpm. An option exists in the block to perform a pre-ANS "set-up" turn in ISH mode prior to commanding to ANS, in order for the ground to specify an initial clock angle about the X axis which will ensure that the CSA views space and is not obscured by Mars. The ISH turn can also be used to facilitate science data gathering for detecting atmospheric disturbances during aerobraking. This option is available for use during the small orbits (orbit periods less than 3 hours), in order to minimize the time in the orbit when star updates are not occurring. After ANS acquisition, the sun monitor ephemeris check is reenabled and the sun angle error timer reset to 30 seconds.

After initiation of the slew, the SAM GDE is commanded back to rate mode and the solar arrays are then commanded back to their cruise positions (i.e., canted 30° towards the spacecraft $+X_b$ axis).

The TWTA is next turned back on. After allowing sufficient time for real-time engineering downlink for acquisition of the signal by the DSN and to determine the health status of the spacecraft, the recorder is then played back at at a fixed 21.3333 ksps playback rate, if this option is selected. After completion of the playback, the XSU is reconfigured for real-time engineering 2 kbps downlink again. An option exists in the block to playback the recorder multiple times if sufficient time is available in the orbit.

If the battery management option was selected going into the drag pass, after the desired battery recharge time, typically 80 minutes at the 7.5 A charge rate, the batteries are disconnected from the BCR and connected back to the alternate trickle charge circuit.

4.5.2 Constraints

1. The CSA/Backup Mode Local Vertical Offset Flag shall be enabled for Aerobraking and the value of the offset quaternion set to (0.0, 0.707106781, 0.0, 0.707106781) to ensure that the spacecraft -Z axis is into the velocity vector and the +X axis is toward zenith.

2. When using the CSA/Backup attitude control mode option, a Mars mapping ephemeris shall be loaded and activated prior to execution of this block.

3. The mapping ephemeris logic shall be enabled in order for CSA/Backup mode to execute.

4. CSA/Backup Mode shall be enabled.

5. The gimbal drive electronics for both solar arrays shall be powered on and their redundancy management enabled, in order for this block to execute properly.

6. The EDF is in engineering mode.

7. The set of PID gains for thruster control in aerobraking must be loaded prior to start of aerobraking.

8. In the event of a hydrazine half string latchout due to a leaking thruster, the thruster configuration flag shall be set prior to execution of this block, to designate which thruster string is to be used for control during the drag pass. The thruster side selection in the block should be consistent with the flight software knowledge of which side is enabled (String Utilization Flag).

9. Control fault thresholds must be set to aerobraking values.

10. The Contingency Mode Actuator Select Flag must be set to thrusters for the aerobraking mission phase.

11. An appropriate Contingency Mode cleanup script must be on-board and enabled prior to execution of this block. The End-of-Drag Indicator must be set to 0 in this script.

12. The desired reaction wheel speeds during the drag pass must be preloaded to obtain a momentum unload approximately at periapsis.

13. The block options AACS_MODE = ISH with a non-zero value for SLEW_RATE and POST_ISH = TRUE,with a non-zero value of POST_RATE shall not be set and used in the same instance of the this block. Attempting to do this, would corrupt the moving target being calculated by the AACS software resulting in erroneous pointing and possible large instantaneous attitude jumps.

14. The block parameter SAM_DLY_PRE shall be set such that the command to put the SAM GDE in powered hold occurs after the arrays have been positioned to their required positions for the drag pass.

15. The total time that the SAM GDE shall be in powered hold or stop mode must not exceed 30 minutes.

16. The XSU PGC bits shall be set for 80 deg modulation index prior to the start of aerobraking.

17. The BCR VT curve shall be set to VT 3 prior to execution of this block.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	DLY_DUR_PRE	INPUT	DUR	hh:mm:ss	00:00:00 - 00:15:00	00:05:00	The timing uncertainty in the predicted periapsis time due to atmospheric and navigation uncertainties. Ensures the spacecraft will be in the proper attitude for the drag pass. This delay time is added to the predicted start of the drag pass.
1.1	DLY_DUR_PST	INPUT	DUR	hh:mm:ss	00:00:00 - 00:15:00	00:05:00	The timing uncertainty in the predicted periapsis time due to atmospheric and navigation uncertainties. Ensures the spacecraft will be in the proper attitude for the reaction wheel enable. This delay time is added to the predicted completion of the drag pass.
1.2	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, before switching to thruster control for the drag pass. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes. Late in aerobraking if power becomes a constraint, the warmup time may be reduced to 20 minutes, but only if both catbed heater strings are enabled. The thrusters are only qualified for 60 cold starts (cold start being defined as an initial catalyst temperature of < 150°F.
1.3	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:05:00 - 00:20:00	00:07:00	Expected slew time to turn the spacecraft 180°, used as the duration of the slew from ANS to the desired drag pass attitude, when the initial ANS attitude is unknown. Does not include settling time.
1.4	TWTA_OFF	INPUT	OFF	hh:mm:ss	00:05:00 - 01:00:00	00:07:30	Offset time from beginning of drag pass to turn the transmitter off during the drag pass.
1.5	TWTA_ON	INPUT	OFF	hh:mm:ss	00:05:00 - 01:00:00	00:07:30	Offset time from end of drag pass to turn the transmitter back on.
1.6	REA_SELECT	INPUT	CHAR	N/A	BOTH ODD EVEN	BOTH	Selects desired REA thruster configuration for control during the aerobraking drag pass. Normally set to BOTH, to utilize both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be enabled for the drag pass.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.7	EXCITER_OFF	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag set to power off the MOT Exciter during the drag pass. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired to power off the Exciter during the drag pass when comm is unavailable. For larger orbits, unnecessary Exciter power cycling is undesirable. Default is TRUE, turning the Exciter OFF for the duration of the drag pass.
1.8	AACS_MODE	INPUT	CHAR	N/A	CSA ISH	CSA	Flag used to set the desired attitude control mode to be used during the drag pass. If the CSA option is selected, the block will configure the spacecraft to maintain a nadir pointed attitude during the drag pass using the mapping phase CSA/Backup mode. This option will set the desired nadir orientation for the drag pass, such that the spacecraft -X axis is maintained along the nadir direction while the +Z axis is maintained along the anti-velocity vector. If the ISH option is selected, the block will command the spacecraft to the ISH mode to slew the spacecraft to a desired inertial attitude at the start of the burn. By setting the ISH slew rate to 0.0, the spacecraft will hold the selected inertial attitude throughout the drag pass. An inertial slew submode option exists in the ISH mode, which may be utilized to simulate a nadir orientation through the drag pass, by setting the ISH slew vector (Parameter No. 1.11 SLEW_VEC) to the spacecraft +Yb axis, and setting the ISH slew rate (Parameter No. 1.10 SLEW_RATE) to approximate the orbital rate.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.9	DRAG_QUAT	INPUT	REAL(4)	N/A	N/A	N/A	Parameter used to set the desired ISH mode inertial attitude quaternion. If Parameter No. 1.8, AACS_MODE is set to CSA, then the block will configure the spacecraft to utilize the mapping CSA/Backup mode to maintain the desired nadir pointing during the drag pass. A constraint exists in the CSA/Backup mode, in that autonomous payload sun avoidance logic is not available. Payload sun avoidance is provided in this option by first transitioning to the ISH mode, to obtain an initial inertial attitude as set by DRAG_QUAT, from which nadir pointing is initiated with the CSA/Backup mode. If AACS_MODE is set to ISH, then DRAG_QUAT represents the desired inertial attitude to be held by the spacecraft during the drag pass.
1.10	SLEW_RATE	INPUT	REAL	rad/sec	0.00004 - 0.0016	N/A	The desired slew rate if using the ISH slew submode option to simulate a nadir orientation throughout the drag pass. Note that when this option is selected the quaternion must be “backed-up” through the rotation angle required to compensate for the timing pads (i.e. SLEW_DUR) and selected rate, in order to have the spacecraft in the desired initial attitude at the start of the drag pass.
1.11	SLEW_VEC	INPUT	REAL(3)	N/A	-1 to 1, -1 to 1, -1 to 1	0,1,0	The desired slew vector if using the ISH slew submode option to simulate a nadir orientation throughout the drag pass.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.12	POST_ISH	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag set to allow an intermediate ANS set up slew (using ISH mode) upon completion of the drag pass, to "set-up" an attitude near the nominal ANS attitude, allowing the ground to optimize the CSA clock angle to avoid stellar obscuration by Mars. This option, if chosen, will typically be used during the small orbit periods, less than 3 hours, to minimize attitude errors associated with minimal star transits. This option could also be used to provide pointing for science after the drag pass.
1.13	POST_QUAT	INPUT	REAL(4)	N/A	N/A	N/A	Parameter used to set the quaternion for the desired post drag ANS "set-up" attitude, if Parameter 1.12 POST_ISH is set to TRUE. The ground will set the quaternion to a near nominal ANS attitude (+Xb axis to the Earth), while setting up the clock angle about the X axis to ensure the CSA is looking at space and not obscured by Mars. This parameter could also be used to provide pointing for science after the drag pass.
1.14	POST_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 00:20:00	00:00:00	Maximum expected slew time to orient the spacecraft to the post drag ANS "set up" attitude, if Parameter 1.12 POST_ISH is set to TRUE. This parameter could also be used in providing pointing for science after the drag pass.
1.15	POST_RATE	INPUT	REAL	rad/sec	0.00004 - 0.0016	N/A	The desired slew rate if using the ISH slew submode option to provide pointing for science after the drag pass.
1.16	POST_VEC	INPUT	REAL(3)	N/A	-1 to 1, -1 to 1, -1 to 1	0,1,0	The desired slew vector if using the ISH slew submode option to provide pointing for science after the drag pass.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.17	SAP_AZ_DRAG	INPUT	REAL	rad	-3.6652 to 2.6180	-0.589048	Desired +Y SA azimuth gimbal angle for the drag pass. Default value is set to -33.75 degrees, to cant the solar array ~30 degrees towards the spacecraft +Z axis. This orientation moves the center-of-pressure aft of the center-of-gravity, providing aerodynamic stability during the drag pass, while ensuring an adequate drag area to successfully perform aerobraking.
1.18	SAP_EL_DRAG	INPUT	REAL	rad	-3.6652 to 2.6180	-3.1416	Desired +Y SA elevation gimbal angle for the drag pass. Default value is set to -180.0 degrees, which places the cells toward the spacecraft +Z axis, protecting them from the incoming flow during the drag pass.
1.19	SAM_AZ_DRAG	INPUT	REAL	rad	-2.6180 to 3.6652	0.89012	Desired -Y SA azimuth gimbal angle for the drag pass. Default value is set to 51 degrees, to cant the solar array 33.75 degrees towards the spacecraft +Z axis (accounts for 20.5 deg unlatched inner panel position due to post-launch deployment anomaly). This orientation moves the center-of-pressure aft of the center-of-gravity, providing aerodynamic stability during the drag pass, while ensuring an adequate drag area to successfully perform aerobraking.
1.20	SAM_EL_DRAG	INPUT	REAL	rad	-2.6180 to 3.6652	0.00000	Desired -Y SA elevation gimbal angle for the drag pass. Default value is set to 0 deg which will place the active cell side of the array into the incoming flow during the drag pass. This is a change to the pre-launch design due to the post-launch deployment anomaly which left the inner panel 20.5 deg away from the desired fully latched position. The new default keeps the aerodynamic force during the drag pass against the hinge obstruction in order to prevent the panel from folding up.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.21	SAP_AZ_ANS	INPUT	REAL	rad	-3.6652 to 2.6180	-0.589048	Desired +Y SA azimuth gimbal angle for the non-drag portion of the orbit (i.e. when the spacecraft is in the ANS attitude). Default value is set to -33.75 degrees, which is unchanged from the drag pass azimuth gimbal angle. This will ensure that the array is always configured to the desired azimuth angle for the drag pass. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired not to cant the solar array 30 degrees towards the spacecraft +X axis, but to leave it normal to the +X axis (0.0 degrees) to allow more solar illumination.
1.22	SAP_EL_ANS	INPUT	REAL	rad	-3.6652 to 2.6180	-1.5708	Desired +Y SA elevation gimbal angle for the non-drag portion of the orbit (i.e. when the spacecraft is in the ANS attitude). Default value is set to -90 degrees, placing the cells toward the spacecraft +X axis.
1.23	SAM_AZ_ANS	INPUT	REAL	rad	-2.6180 to 3.6652	-0.23126	Desired -Y SA azimuth gimbal angle for the non-drag portion of the orbit (i.e. when the spacecraft is in the ANS attitude). Default value is set to -13.25 degrees, to cant the solar array 33.75 degrees towards the spacecraft +X axis (accounts for the 20.5 deg unlatched inner panel position due to post-launch deployment anomaly). For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired not to cant the solar array 30 degrees towards the spacecraft +X axis, but to leave it normal to the +X axis (0.0 degrees) to allow more solar illumination.
1.24	SAM_EL_ANS	INPUT	REAL	rad	-2.6180 to 3.6652	1.5708	Desired -Y SA elevation gimbal angle for the non-drag portion of the orbit (i.e. when the spacecraft is in the ANS attitude). Default value is set to +90 degrees, placing the cells toward the spacecraft +X axis.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.25	REC_SEL	INPUT	INT	N/A	REC_1A REC_1B REC_2A REC_2B NA	REC_1A	Parameter used to select the desired recorder for recording the aerobraking events. If REC_SEL is set to NA, then the record/playback option in the block will not be selected. In this block, the record and playback options are interrelated. For example, there is no option to record but not play back.
1.26	PB1_DELAY	INPUT	DUR	hh:mm:ss	00:02:10 - 24:00:00	01:00:00	After reacquiring Earth pointing, the amount of time allocated to real-time 2 kbps engineering downlink, before playing back the engineering telemetry recorded on the SSR. Set if Parameter 1.25 REC_SEL is not equal to NA.
1.27	SECND_PB	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to specify a second (redundant) playback of the recorded engineering on the SSR, if sufficient time available in the orbit. Set if Parameter 1.25 REC_SEL is not equal to NA.
1.28	PB2_DELAY	INPUT	DUR	hh:mm:ss	00:00:10 - 24:00:00	00:00:10	The delay time from completion of the first SSR playback until the start of the second redundant playback. If the second playback option is selected, Parameter No. 1.27 SECND_PB is set to TRUE. Typically, this parameter shall be set so that the second playback will not occur within the ABM window.
1.29	THIRD_PB	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to specify a third (second redundant) playback of the recorded engineering on the SSR, if sufficient time available in the orbit. Set if Parameter 1.25 REC_SEL is not equal to NA.
1.30	PB3_DELAY	INPUT	DUR	hh:mm:ss	00:00:10 -24:00:00	00:00:10	The delay time from completion of the second SSR playback until the start of the third (second redundant) playback. If the third playback option is selected, Parameter No. 1.29 THIRD_PB is set to TRUE. Typically, this parameter shall be set so that the third playback will not occur within the ABM window.
1.31	EDF_SIDE	INPUT	CHAR	N/A	EDF_1 EDF_2	EDF_1	Parameter used to specify which side of the EDF is on and sending telemetry to the SSR for recording.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.32	TACH_DELAY	INPUT	DUR	hh:mm:ss	0 to DRAG_DUR	N/A	Parameter used to specify the delay time from beginning of drag pass until the momentum unload will occur. Typically set to DRAG_DUR / 2.
1.33	SAM_PWR_HOLD	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to select the gimbal powered hold option for the -Y SA GDE during the drag pass. Due to the -Y SA failing to latch during deployment, the GDE imust be commanded to stop mode prior to entry into the drag pass in order to provide sufficient holding torque against the aerodynamic forces during the drag pass.
1.34	SAM_DLY_PRE	INPUT	DUR	hh:mm:ss	00:00:00 - 00:15:00	00:05:00	The delay time prior to the start of the drag pass to command the SAM GDE to stop mode (i.e., powered hold).
1.35	SAM_DLY_PST	INPUT	DUR	hh:mm:ss	00:00:00 - 00:15:00	00:06:00	The delay time upon completion of the drag pass to command the SAM GDE out of stop mode (i.e., powered hold) and back to rate mode.
1.36	BATT_CONFIG	INPUT	CHAR	N/A	BCR N/A	BCR	Option used to connect the batteries to the BCR prior to the drag pass to allow the batteries to be recharged at the higher BCR rates upon completion of the drag pass. After sufficient recharge time (Parameter 1.37 BCR_DUR), the batteries are disconnected from the BCR and connected to the 0.18A trickle charger. This option is to be used throughout aerobraking until the orbit period reaches approximately two hours.
1.37	BCR_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 03:00:00	02:00:00	Desired duration to leave the batteries connected to the BCR for recharging at the higher BCR rates upon ANS reacquisition after the drag pass. This duration shall be set sufficiently long to ensure the batteries are fully charged but not so long as to overcharge/overheat the batteries. Two hours is the predicted default value for this parameter.
1.38	BCR_SIDE	INPUT	CHAR	N/A	BCR_1 BCR_2	BCR_1	Parameter used to determine which BCR is currently in use, either the primary or backup, when reconnecting the batteries to the BCR for the drag pass.

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
1.39	BATT_STATUS	INPUT	CHAR	N/A	BOTH_OK BAT1_OK BAT2_OK	BOTH_OK	Parameter used to determine the operational status of the batteries when connecting and disconnecting the batteries from the BCR.
2.0	PERIAPSIS	PDB (OPTG)	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Predicted time of periapsis passage. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
2.1	DRAG_DUR	PDB (OPTG)	DUR	hh:mm:ss	00:00:00 - 00:30:00	N/A	Predicted duration that the spacecraft will be in the Mars atmosphere during the orbital drag pass.
3.0	DRAG_START	CALC	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Predicted time of atmospheric entry, equal to predicted periapsis time minus half of the predicted drag duration. DRAG_START = PERIAPSIS - (DRAG_DUR / 2)

3.1	REA_ODD	CALC	FLAG	N/A	TRUE
					FALSE
						N/A	Parameter used to determine whether the odd string of 4.4 N engines (1,3,5,7,9,12) are to be enabled and armed for the drag pass, calculated from the REA thruster configuration selection, Parameter No. 1.6 REA_SELECT.
							
							IF (REA_SELECT = BOTH OR ODD) THEN
							REA_ODD = TRUE
							END IF

3.2	REA_EVEN	CALC	FLAG	N/A	TRUE
					FALSE
						N/A	Parameter used to determine whether the even string of 4.4 N engines (2,4,6,8,10,11) are to be enabled and armed for the drag pass, calculated from the REA thruster configuration selection, Parameter No. 1.6 REA_SELECT.
							
							IF (REA_SELECT = BOTH OR EVEN) THEN
							REA_EVEN = TRUE
							END IF

Parameter Table (AEROBRAKE)

No	Name	Source	Type	Units	Range	Default	Definition
3.3	PB_DUR	CALC	DUR	hh:mm:ss	N/A	N/A	The required time to playback the recorded 2 kbps engineering telemetry stream on the SSR. Calculated from the total time the transmitter was turned off. Assuming a 21.333 ksps playback rate: PB_DUR = (DRAG_DUR + DLY_DUR_PRE + DLY_DUR_PST +00:35:00 + TWTA_ON+ 00:02:00) / 10.666

3.4	PATH_SEL	CALC	CHAR	N/A	BOTH_PRI
					BAT1_PRI
					BAT2_PRI
					BOTH_BUP
					BAT1_BUP
					BAT2_BUP
						N/A	Parameter used to select the correct charge path when reconnecting the batteries to the BCR. Calculated from the BCR and battery status parameters, Param1.38 and 1.39 respectively.
							
							IF (BCR_SIDE = BCR_1) THEN
							IF (BATT_STATUS = BOTH_OK) THEN
							PATH_SEL = BOTH_PRI
							ELSE IF (BATT_STATUS = BAT1_OK) THEN
							PATH_SEL = BAT1_PRI
							ELSE IF (BATT_STATUS = BAT2_OK) THEN
							PATH_SEL = BAT2_PRI
							ELSE
							IF (BATT_STATUS = BOTH_OK) THEN
							PATH_SEL = BOTH_BUP
							ELSE IF (BATT_STATUS = BAT1_OK) THEN
							PATH_SEL = BAT1_BUP
							ELSE IF (BATT_STATUS = BAT2_OK) THEN
							PATH_SEL = BAT2_BUP
							END IF

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of AEROBRAKE block execution.
2.0	IF (REC_SEL ≠ NA) THEN		TEST		
2.0.1	clear partitions on selected recorder recorder = REC_SEL mode = clear partitions		STSSRC	T = DRAG_START - DLY_DUR_PRE - 00:35:02	Clear partitions on selected recorder prior to recording.
2.0.2	begin recording on selected recorder recorder = REC_SEL clock = EDF_SIDE mode = record partition = 1		STSSRC	T = DRAG_START - DLY_DUR_PRE - 00:35:01	Begin recording 2 kbps engineering telemetry from the EDF on partition 1 of the desired recorder.
2.0.3	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = DRAG_START - DLY_DUR_PRE - 00:35:00	Enable selected recorder to receive telemetry for recording.
2.1	END IF		TEST		
3.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), nominally 30 min prior to switching from RWA to thruster control.
3.0.1	enable REA & catbed heater no 1		PRC01E	T = DRAG_START - DLY_DUR_PRE - CATBED_DUR - 00:00:01	
3.0.2	enable REA & catbed heater no 3		PRC03E		
3.0.3	enable REA & catbed heater no 5		PRC05E		
3.0.4	enable REA & catbed heater no 7		PRC07E		
3.0.5	enable REA & catbed heater no 9		PRC09E		
3.0.6	enable REA & catbed heater no 12		PRC12E		
3.1	END IF		TEST		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) nominally 30 min prior to switching from RWA to thruster control.
3.2.1	enable REA & catbed heater no 2		PRC02E	T = DRAG_START - DLY_DUR_PRE - CATBED_DUR	
3.2.2	enable REA & catbed heater no 4		PRC04E		
3.2.3	enable REA & catbed heater no 6		PRC06E		
3.2.4	enable REA & catbed heater no 8		PRC08E		
3.2.5	enable REA & catbed heater no 10		PRC10E		
3.2.6	enable REA & catbed heater no 11		PRC11E		
3.3	END IF		TEST		
4.0	turn TWTA beam off		STRPAF	T = DRAG_START - DLY_DUR_PRE - TWTA_OFF	Turn off TWTA beam.
4.1	IF (EXCITER_OFF = TRUE) THEN		TEST		
4.1.1	turn MOT exciter off		STMOTF		Option to turn off the Exciter for power conservation, at the expense of the potential adverse effects resulting from power cycling the component.
4.2	END IF		TEST		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	IF (BATT_CONFIG = BCR) THEN		TEST		Until the orbit period has decreased to 2 hours, the battery configuration option must be selected to connect the batteries to the BCR prior to each drag pass discharge period. After sufficient recharge time upon returning to ANS after the drag pass (typically 80 min) the batteries are disconnected from the BCR and connected to the alternate .18A trickle charge circuit.
5.0.1	turn off 0.18 A alternate trickle charge circuit to both batteries		PWB1TF PWB2TF	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:01:03	Disconnect both batteries from alternate trickle charge path.
5.0.2	disable 0.18 A alternate trickle charge circuit to both batteries		PWB1TX PWB2TX	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:01:02	Disable the alternate trickle charge circuit to both batteries.
5.0.3	set BCR charge rate to 7.5 A battery select = BATT_STATUS		SWBCRS	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:01:01	Set the BCR to the 7.5 A charge rate for recharge after the drag pass.
5.0.4	connect batteries to BCR charge_path_select = PATH_SEL		SWCHPS	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:01:00	Connect batteries to the BCR.
5.1	END IF		TEST		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0	IF (AACS_MODE = CSA) THEN		TEST		Perform option for nadir attitude control during the drag pass. This option utilizes the mapping CSA/Backup mode to maintain the proper drag pass nadir attitude, in which the spacecraft -X axis is pointed in the nadir direction, with the +Z axis maintained along the anti-velocity vector.
6.0.1	load ISH control parameters rate = 0.0		SALICP	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:32	The ISH attitude control mode, which has autonomous payload sun avoidance logic, is utilized to achieve an initial nadir inertial attitude from which CSA/Backup mode can be initiated. The slew rate for the ISH/pitch option is set to zero.
6.0.2	load ISH control parameters quaternion = DRAG_QUAT		SALICP	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:31	Load the quaternion for the desired initial inertial attitude from which to initiate nadir pointing control with the CSA/Backup mode, at the start of the drag pass.
6.0.3	set attitude control state to ISH		SAGISH	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:30	Attitude control software will slew to the desired attitude loaded in Event No. 6.0.2, using the reaction wheels.
6.0.4	disable star processing		SASTRX	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:29	Star identification and processing is disabled during the drag pass.
6.0.5	disable sun monitor ephemeris check		SASMEX	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:28	Disable sun monitor ephemeris check during the drag pass to prevent undesired REDMAN swapping of the SSA due to the planet's albedo confusing the SSA into thinking Mars is the sun.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0.6	increase sun angle error timer address = 0x2768 dataword = 0x1C20		SCGNLD		Increase the sun angle error timer to 60 minutes to prevent undesired REDMAN swapping of the SSA during the drag pass due to the planet's albedo confusing the SSA into thinking Mars is the sun.
6.0.7	set attitude control state to CSA/Backup		SAGCSA	T= DRAG_START - DLY_DUR_PRE - 00:00:30	The desired spacecraft nadir attitude, preset to align the -Xb axis along the nadir direction and the -Zb axis along the spacecraft velocity vector, is maintained using the mapping phase CSA/Backup attitude control mode. In this mode, attitude control errors are derived from the star processing task generated inertial-to-body quaternion and the mapping orbit ephemeris derived orbit angles.
6.1	ELSE		TEST		Perform inertial attitude option during drag pass.
6.1.1	load ISH control parameters rate = SLEW_RATE vector = SLEW_VEC		SALICP	T= DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:02	Load the quaternion for the desired drag pass inertial attitude. The ISH pitch rate is typically set to zero for an inertial attitude through the drag pass. An option does exist to initiate a rate about a selected axis upon acquiring the desired initial attitude.
6.1.2	load ISH control parameters quaternion = DRAG_QUAT		SALICP	T= DRAG_START - DLY_DUR_PRE - SLEW_DUR - 00:00:01	If the ISH/Pitch option is selected (i.e., a desired rate and vector input in the preceding event), the quaternion must be "backed-up" through the rotation angle required to compensate for the timing pads (i.e. SLEW_DUR) at the selected slew rate.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.1.3	set attitude control state to ISH		SAGISH	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR	Attitude control software will slew to the desired attitude loaded in Event No. 6.1.2, using the reaction wheels. Worst case slew time for a 180 deg turn is about 7.5 minutes. This does not include settling time (typically another few minutes). In ISH mode, nominal momentum unloading is disabled, although emergency unloading is available. Additionally in ISH mode, star processing is disabled.
6.2	END IF		TEST		
7.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_DRAG inboard gimbal angle = SAP_EL_DRAG		SALPTA	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + 00:00:58	Load the desired aerobraking gimbal target angles for the inboard and outboard gimbals of the +Yb mounted solar array.
7.1	load -Yb solar array gimbal drive target angles outboard gimbal angle =SAM_AZ_DRAG inboard gimbal angle = SAM_EL_DRAG		SALMTA	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + 00:00:59	
7.2	enable +Yb SA manual gimbal drive rate control		SAPRCE	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + 00:01:00	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the inboard and outboard gimbals will move to the target angles loaded in Events 7.0 and 7.1 at the times the target angles are loaded.
7.3	enable -Yb SA manual gimbal drive rate control		SAMRCE		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.0	switch IMU to accelerometer output format		SRACCF	T = DRAG_START - DLY_DUR_PRE - 00:00:20	The IMU is switched to accelerometer output for the drag pass. The accelerometer data provides an important measurement for reconstructing the atmospheric density throughout the pass.
8.1	enable frozen gyro check		SAFIME		The frozen gyro check is enabled whenever the IMU is in accelerometer output format, in which the 6 gyro co-channel compare ability is not available. Enabling the check allows the flight software to select backup gyro axis data if the gyro output remains unchanged for a selected number of consecutive cycles.
9.0	IF (SAM_PWR_HOLD = TRUE) THEN		TEST		Due to the -Y SA failing to latch during its post launch deployment, the -Y SA GDE is commanded to stop mode (i.e., powered hold) prior to entry into the drag pass in order to provide sufficient holding torque against the aerodynamic forces during the drag pass.
9.0.1	switch -Y SA GDE to Stop Mode		SAMSCE	T = DRAG_START - SAM_DLY_PRE	Command the -Y SA GDE to stop mode.
9.1	END IF		TEST		
10.0	turn off ER High Voltage Datawords = MAG_A, hB003, h0943, h012F, h0001, h0130		SCPDSC	T = DRAG_START - DLY_DUR_PRE - 00:06:30 + DRAG_DUR/2	The ER is on during the large orbits of aerobraking (down to the 10 hour orbit period). In order to prevent possible damage due to arcing below 150 km, the ER high voltage is turned off at approximately 300 km. This is equivalent to approximately Periapsis minus 6 mintues.
10.1	set ER to Aerobraking Mode Datawords = MAG_A, hB003, h09DC, h05C8, h1C05, h21CD		SCPDSC	T = DRAG_START - DLY_DUR_PRE - 00:06:30 + DRAG_DUR/2 + 00:00:01	The ER is placed into aerobraking mode during the period of time the spacecraft is below 300 km (fixed at 13 minutes).

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
11.0	IF (REA_ODD) THEN		TEST		Re-enable the odd thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off and the thrusters disabled.
11.0.1	enable REA & catbed heater no 1		PRC01E	T= DRAG_START - DLY_DUR_PRE - 00:00:03	
11.0.2	enable REA & catbed heater no 3		PRC03E		
11.0.3	enable REA & catbed heater no 5		PRC05E		
11.0.4	enable REA & catbed heater no 7		PRC07E		
11.0.5	enable REA & catbed heater no 9		PRC09E		
11.0.6	enable REA & catbed heater no 12		PRC12E		
11.0.7	arm REAs 1,3,5,7,9,12		PRTHOA	T= DRAG_START - DLY_DUR_PRE - 00:00:01	
11.1	END IF		TEST		
11.2	IF (REA_EVEN) THEN		TEST		Re-enable the even thrusters and turn on their catbed heaters.
11.2.1	enable REA & catbed heater no 2		PRC02E	T= DRAG_START - DLY_DUR_PRE - 00:00:02	
11.2.2	enable REA & catbed heater no 4		PRC04E		
11.2.3	enable REA & catbed heater no 6		PRC06E		
11.2.4	enable REA & catbed heater no 8		PRC08E		
11.2.5	enable REA & catbed heater no 10		PRC10E		
11.2.6	enable REA & catbed heater no 11		PRC11E		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
11.2.7	arm REAs 2,4,6,8,10,11		PRTHEA	T= DRAG_START - DLY_DUR_PRE - 00:00:01	
11.3	END IF		TEST		
12.0	set end of drag indicator to 'drag'		SAEODD	T= DRAG_START - DLY_DUR_PRE	Set the attitude control gains for the drag pass.
12.1	set actuator select flag to thruster control		SAASFT	T= DRAG_START - DLY_DUR_PRE	Switch from reaction wheel control to thruster control for the drag pass. The wheel speeds are held at their current values.
	DRAG PASS				
12.2	set tach hold mode		SATACH	T= DRAG_START + TACH_DELAY	Command all 4 wheel speeds to values previously loaded prior to execution of this block, to obtain momentum unload during drag pass. TACH_DELAY is set to cause the unload to occur near peak aerodynamic loading to minimize the effects of the wheel spindown.
12.3	set end of drag indicator to 'post-drag'		SAEODP	T= DRAG_START + DRAG_DUR	Tighten the pointing gains back down at the predicted end of sensible drag, to dampen the rates for transitioning back to reaction wheel control.
12.4	set actuator select flag to RWA control		SAASFW	T= DRAG_START + DRAG_DUR + DLY_DUR_PST	Switch back to reaction wheel control upon completion of the post-drag delay segment.
12.5	set end of drag indicator to 'no drag'		SAEODF		Set the attitude control gains for the vacuum portion of the orbit.
13.0	disarm REAs 1,3,5,7,9,12		PRTHOD		Disarm and disable all of the thrusters and their catbed heaters.
13.1	disarm REAs 2,4,6,8,10,11		PRTHED		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
13.2	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:01	
13.3	disable REAs & catbed heaters no 2,4,6		PRCTBX		
13.4	disable REAs & catbed heaters no 7,9,12		PRCTCX		
13.5	disable REAs & catbed heaters no 8,10,11		PRCTDX		
14.0	switch IMU to all-gyro output format		SRAGYF	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:02	Switch the IMU back to “all-gyro” output format.
14.1	disable frozen gyro check		SAFIMX		Disable frozen gyro check.
15.0	IF (POST_ISH) THEN		TEST		Determine whether it is desired to execute the ANS “set-up” turn to ensure the CSA field of view will not be obscured by Mars upon initiating ANS, or to point for science.
15.0.1	reset accumulated slew angle		SARASA	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:03	Accommodates a constraint in the AACS flight software.
15.0.2	load ISH control parameters rate = POST_RATE vector = POST_VEC		SALICP	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:04	Set the ISH rate and vector for the slew to the post-drag attitude.
15.0.3	load ISH control parameters quaternion = POST_QUAT		SALICP	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:05	Load the quaternion for the ANS set up attitude to ensure the CSA will avoid stellar obscuration by Mars.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
15.0.4	set attitude control state to inertial slew/hold (ISH)		SAGISH	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:06	
15.0.5	set attitude control state to array normal spin (ANS)		SAGANS	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + POST_DUR	Command back to normal cruise array normal spin attitude control mode upon completion of the CSA FOV set up slew (+X axis aligned with the ephemeris generated earth vector).
15.0.6	enable star processing		SASTRE	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + POST_DUR + 00:00:01	Re-enable star processing. Note however, that ANS will inhibit star processing until the cruise target attitude has been reached.
15.0.7	enable sun monitor ephemeris check		SASMEE	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + POST_DUR + 00:10:00	Reenable sun monitor ephemeris check upon returning to ANS.
15.0.8	decrease sun angle error timer address = 0x2768 dataword = 0x003C		SCGNLD		Reset the sun angle error timer to 30 seconds
15.1	ELSE		TEST		
15.1.1	set attitude control state to array normal spin (ANS)		SAGANS	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:03	Command back to normal cruise array normal spin attitude control mode upon completion of the drag pass (+X axis aligned with the ephemeris generated earth vector).
15.1.2	enable star processing		SASTRE	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:00:04	Re-enable star processing. Note however, that ANS will inhibit star processing until the cruise target attitude has been reached.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
15.1.3	enable sun monitor ephemeris check		SASMEE	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + 00:10:00	Reenable sun monitor ephemeris check upon returning to ANS.
15.1.4	decrease sun angle error timer address = 0x2768 dataword = 0x003C		SCGNLD		Reset the sun angle error timer to 30 seconds.
15.2	END IF		TEST		
16.0	IF (SAM_PWR_HOLD = TRUE) THEN		TEST		
16.0.1	enable -Yb SA manual gimbal drive rate control		SAMRCE	T= DRAG_START + DRAG_DUR + SAM_DLY_PST	End powered hold, return to rate mode control.
16.1	END IF		TEST		
16.2	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_ANS inboard gimbal angle = SAP_EL_ANS		SALPTA	T= DRAG_START + DRAG_DUR + SAM_DLY_PST + 00:00:01	Load the desired gimbal target angles for the inboard and outboard gimbals of the +Yb mounted solar array, to orient the solar arrays back to their cruise positions.
16.3	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_ANS inboard gimbal angle = SAM_EL_ANS		SALMTA	T= DRAG_START + DRAG_DUR + SAM_DLY_PST + 00:00:02	
17.0	turn on ER High Voltage Datawords = MAG_A, B003, 09C1, 012F, 0000, 012F		SCPDSC	T= DRAG_START + DLY_DUR_POST + 00:06:30 + DRAG_DUR/2	The ER High Voltage is turned on after periapsis when the altitude is equal to 300 km.
18.0	turn TWTA beam on		STRPAN	T= DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON	Turn the TWTA back on after the drag pass. This command also turns the MOT Exciter on if it had been turned off during the drag pass for power conservation.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0	IF (REC_SEL ≠ NA) THEN		TEST		Begin playback of recorded telemetry if record/playback option selected.
19.0.1	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + 00:02:00	Disable recording on selected recorder (i.e., set to standby).
19.0.2	set XSU mode for playback from selected recorder source = REC_SEL		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY - 00:00:02	Configure the XSU to send the telemetry from the selected recorder to the MOT.
19.0.3	IF (REC_SEL = REC_2B) THEN		TEST		
19.0.3.1	configure recorder 2A's clock for recorder 2B playback recorder = REC_2A clock = 21_Khz mode = enable scrub partition = 1		STSSRC		The 2B recorder must use the 2A recorder clock to perform telemetry playback due to a heritage idiosyncrasy in the XSU to recorder interface design.
19.0.4	END IF		TEST		
19.0.5	begin playback from selected recorder recorder = REC_SEL clock = 21_Khz mode = playback partition = 1		STSSRC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY - 00:00:01	Begin playback at the 21.3 kbps rate from partition 1 of the selected recorder.
19.0.6	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY	Enable selected recorder for playback.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.7	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR	Disable selected recorder from playing back (i.e., set to standby).
19.0.8	set XSU mode for EDF real-time transmission source = EDF_SIDE		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + 00:00:01	
19.0.9	IF (SECND_PB) THEN		TEST		If orbital period is large enough, perform a second (redundant) playback of the recorded drag pass telemetry.
19.0.9.1	enable scrub for selected recorder recorder = REC_SEL clock = 21_KHz mode = enable scrub partition = 1		STSSRC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:03	Prior to performing redundant playback, the SSR state must be reset to something other than playback (i.e., enable scrub) in order for the playback command to work.
19.0.9.2	set XSU mode for playback from selected recorder source = REC_SEL		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:02	Configure the XSU to send the telemetry from the selected recorder to the MOT.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.9.3	IF (REC_SEL = REC_2B) THEN		STATE		
19.0.9.3.1	configure recorder 2A's clock prior to playback recorder = rec 2A clock = 21_KHz mode = enable scrub partition = 1		STSSRC		The 2B recorder must use the 2A recorder clock to perform telemetry playback due to a heritage idiosyncracy in the XSU to recorder interface design.
19.0.9.4	END IF		TEST		
19.0.9.5	begin playback from selected recorder recorder = REC_SEL clock = 21_KHz mode = playback partition = 1		STSSRC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:01	Begin playback at 21.3 kbps from partition 1 of the selected recorder.
19.0.9.6	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY	Enable selected recorder for playback.
19.0.9.7	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR	Disable selected recorder from playing back (i.e., set to standby).

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.9.8	set XSU mode for EDF real-time transmission source = EDF_SIDE		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + 00:00:01	
19.0.10	END IF		TEST		
19.0.11	IF (THIRD_PB) THEN		TEST		If orbital period is larger still, perform a third (second redundant) playback of the recorded drag pass telemetry.
19.0.11.1	enable scrub for selected recorder recorder = REC_SEL clock = 21_KHz mode = enable scrub partition = 1		STSSRC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY - 00:00:03	Prior to performing redundant playback, the SSR state must be reset to something other than playback (i.e., enable scrub) in order for the playback command to work.
19.0.11.2	set XSU mode for playback from selected recorder source = REC_SEL		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY - 00:00:02	Configure the XSU to send the telemetry from the selected recorder to the MOT.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.11.3	IF (REC_SEL = REC_2B) THEN		STATE		
19.0.11.3.1	configure recorder 2B's clock prior to playback recorder = rec 2A clock = 21_KHz mode = enable scrub partition = 1		STSSRC		The 2B recorder must use the 2A recorder clock to perform telemetry playback due to a heritage idiosyncracy in the XSU to recorder interface design.
19.0.11.4	END IF		TEST		
19.0.11.5	begin playback from selected recorder recorder = REC_SEL clock = 21_KHz mode = playback partition = 1		STSSRC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY - 00:00:01	Begin playback at 21.3 kbps from partition 1 of the selected recorder.
19.0.11.6	enable data on recorder 1A	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY	Enable selected recorder for playback.

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.11.7	disable data on recorder 1A	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY + PB_DUR	Disable selected recorder from playing back (i.e., set to standby).
19.0.11.8	set XSU mode for EDF real-time transmission source = EDF_SIDE		STMOTC	T = DRAG_START + DRAG_DUR + DLY_DUR_PST + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + PB3_DELAY + PB_DUR + 00:00:01	
19.0.12	END IF		TEST		
19.1	END IF		TEST		

Event Table (AEROBRAKE)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
20.0	IF (BATT_CONFIG = BCR) THEN		TEST		Until the orbit period has decreased to 2 hours, the battery configuration option must be selected to connect the batteries to the BCR prior to each drag pass discharge period (i.e. when initial slew off of ANS is performed). After sufficient recharge time upon returning to ANS after the drag pass (typically 80 min) the batteries are disconnected from the BCR and connected to the alternate .18A trickle charge circuit.
20.0.1	disconnect both batteries from the BCR address = h2464 dataword value = h8440		SISERC	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + BCR_DUR	Disconnect both batteries from the BCR.
20.0.2	enable 0.18 A alternate trickle charge circuit to both batteries		PWB1TE PWB2TE	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + BCR_DUR + 00:00:01	Enable the alternate trickle charge circuit to both batteries.
20.0.3	turn on 0.18 A alternate trickle charge circuit to both batteries		PWB1TN PWB2TN	T = DRAG_START - DLY_DUR_PRE - SLEW_DUR + BCR_DUR + 00:00:02	Connect both batteries to the alternate trickle charge path.
20.1	END IF		TEST		
21.0	END BLOCK		STATE		Completion of AEROBRAKE block execution.

State Table (AEROBRAKE)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	ANS	ISH » CSA/Backup (Default) ISH» CSA/BU» ISH (Optional) ISH (Optional)	ANS
	Actuator Select Flag	RWAs	Thrusters	RWAs
	Local Vertical Offset Flag	Enabled		Enabled
	Local Vertical Offset Quaternion	(0.0, 0.707106781, 0.0, 0.707106781)		(0.0, 0.707106781, 0.0, 0.707106781)
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)		All Gyro (6 gyro channels)
	IMU Rate Mode	High Rate Mode		High Rate Mode
	IMU Frozen Gyro Check	Disabled		Disabled
	Star Processing	Enabled	Disabled in ISH (autonomous function), Disabled in CSA/Backup (by Block)	Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)	RWAs in Tach Hold Mode during Burn (autonomous function)	3 On, 1 Off (normally skew wheel)
	MHSA Power State	Off		Off
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On	On / Manual Rate Mode	On
	HGA GDE Power State / Control Mode	Off		Off
	HGA GDE Control Mode	Disabled		Disabled
	Sun Avoidance	Enabled	Disabled (autonomous function in CSA/Backup mode)	Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled

State Table (AEROBRAKE)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH				
	EDF Mode	Engineering Mode (2 Kbps Telemetry Rate)		Engineering Mode (2 kbps Telemetry Rate)
	XSU Mode	EDF Telemetry to MOT for Real-time Downlink PDS Telemetry to SSR for Recording during MAG Data Collection Period of Aerobraking	EDF Telemetry to SSR for Recording » SSR Telemetry to MOT for Playback » EDF Telemetry to MOT for Real-time Downlink » SSR Telemetry to MOT for Optional second Playback	EDF Telemetry to MOT for Real-time Downlink PDS Telemetry to SSR for Recording during MAG Data Collection Period of Aerobraking
	SSR Power State / Mode	1 Recorder On / Standby Additional Recorder On / Recording PDS Telemetry during MAG Data Collection Period of Aerobraking	Record EDF Telemetry » Playback (21 kbps) » Standby » Optional second Playback(21 kbps)	1 Recorder On / Standby Additional Recorder On / Recording PDS Telemetry during MAG Data Collection Period of Aerobraking
	PDS Power State / Mode	On / LRC (Low Rate Record - 4 Ksps) during MAG Data Collection Period of Aerobraking		On / LRC (Low Rate Record - 4 Ksps) during MAG Data Collection Period of Aerobraking
Propulsion	Note NC = Normally Closed NO = Normally Open			
	Helium Pressurant Latch Valve 1 & Redundant Pyro Valve 1 (NC)	Opened Not Fired unless LV 1 fails closed		Opened Not Fired unless LV 1 fails closed
	RCS thruster Latch Valves 2 & 3	Both Open unless leaky thruster detected		Both Open unless leaky thruster detected
	Main Engine Latch Valves 4 & 5 & Redundant Pyro Valves 13 & 14 (NC)	Closed Not fired unless LV4 or LV5 fail closed		Closed Not fired unless LV4 or LV5 fail closed

State Table (AEROBRAKE)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Propulsion (continued)	Pressurant Isolation Pyro Valves 2 through 6	PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Regulator Isolation Pyro Valves 7 through 9	PV 7 (NO) Not Fired unless Primary Regulator leak detected PV 8 (NC) Not Fired unless Backup Regulator brought on line PV 9 (NC) Not Fired unless Backup Regulator brought on line		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Oxidizer Isolation Pyro Valves 10 through 12	PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required		PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required
	Main Engine	Disabled and Disarmed		Disabled and Disarmed
	RCS Thrusters odd string (1,3,5,7,9,12) even string (2,4,6,8,10,11)	Disabled and Disarmed Disabled and Disarmed	Both Strings Enabled and Armed (unless a string latched out due to leaky thruster)	Disabled and Disarmed Disabled and Disarmed

State Table (AEROBRAKE)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Thermal				
	RCS Thruster Catbed Heaters * odd string (1,3,5,7,9,12) even string (2,4,6,8,10,11) * Note that each thruster has its own catbed heater, that is turned on when the thruster is enabled	Off Off	Both Strings On (unless a string latched out due to leaky thruster)	Off Off
	Main Engine Injector Heaters	Off		Off
Telecom	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna	HGA		HGA
	TWTA 1 Filament	Off		Off
	TWTA 1 Beam	Off		Off
	TWTA 2 Filament	On		On
	TWTA 2 Beam	On	Off	On
	MOT 1 Exciter	Off		Off
	MOT 2 Exciter	On	Off (If option selected)	On
	MOT Noncoherent Mode	Off		Off
	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	On		On
	MOT Ranging	On		On

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4.6 ABM - Aerobrake Maneuver Block

4.6.1 Block Description

During the aerobraking phase, the periapsis altitude must be maintained within a desired control corridor, which balances spacecraft thermal and dynamic pressure constraints against the drag forces required to affect the necessary orbit reduction. The ABM block is used to perform periodic propulsive maneuvers at apoapsis to maintain the desired periapsis altitude.

All events in the block are timed relative to the start of the engine firing.

The first event in the block is to warmup the catbed heaters of the 4.4 N thrusters to be used for the maneuver. Depending on the configuration of the propulsion system, the block has an option to use all twelve of the thrusters or in the event of a half-side latch out, either the odd or even string of thrusters. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used.

Immediately prior to the start of the turn to the desired maneuver attitude, the TWTA will be turned off due to power limitations. The block has an option to power off the MOT Exciter during the maneuver. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired to power off the Exciter during the maneuver when communications are unavailable. For larger orbits, unnecessary Exciter power cycling is undesirable. Note that current flight software turns off the Exciter when the TWTA beam is turned off. Until the (approved) change to disconnect ‘Exciter off’ from ‘TWTA beam off’ is incorporated, the Exciter will be powered off for the maneuver regardless of this option.

One minute prior to turning the TWTA off, a recorder is configured for recording of engineering 2000 bps telemetry throughout the period of no telemetry downlink. Options exist in the block to not record or playback the ABM events.

Several minutes prior to the start of the turn to the ABM burn attitude, the batteries are disconnected from the 0.18 A alternate trickle charger, the BCR charge rate set to 7.5 A and the batteries reconnected to the BCR. This will allow the batteries to immediately and quickly recharge upon reacquisition of ANS after the maneuver. The battery_BCR configuration is optional in the block and is intended to be used while the orbit period is greater than 2 hours. During the end-game, the batteries will always remain connected to the BCR.

The flight software maneuver control parameters are loaded next, and include the desired burn attitude, delta V, and minimum and maximum burn times. Attitude control is then commanded to the ISH attitude control mode to turn the spacecraft to the desired burn attitude, under reaction wheel control. The turn to the burn attitude should be accomplished in about 10 minutes for a worst case 180° turn.

Once the spacecraft has begun the slew to the aerobraking attitude, the solar arrays are oriented to their required positions for the burn. The solar arrays are canted 30° towards the spacecraft $-Z_b$ axis in order to optimize the center of mass for the burn. The solar arrays are each commanded in the manual rate mode to an absolute azimuth and elevation gimbal position. Relative to the arrays' cruise positions, each arrays' elevation gimbal will be rotated 90°.

Two minutes prior to the start of the burn, the IMU is switched to the accelerometer output format, in which the IMU will output three channels of gyro data and three channels of accelerometer data to the flight software. The IMU must be in this format so the flight software maneuver task can process accelerometer telemetry from the IMU during the burn and determine delta V accumulation and maneuver cutoff time. Next, the IMU frozen gyro check is enabled. While the IMU is in accelerometer output format, the 6 gyro co-channel compare ability is not available. Enabling the frozen gyro check allows the flight software to select the backup gyro axis if the gyro output is identical for 10 consecutive cycles and thus safely continue the burn. Next, an accelerometer calibration is performed. The accumulated delta Vs are first zeroed and then the delta Vs measured from each accelerometer over a selected period of time (nominally 100 seconds), to determine the accelerometer bias on each accelerometer.

Three seconds prior to the start of the pre-drag delay segment, the 4.4 N thrusters are re-enabled and their catbed heaters turned back on, in the event an emergency momentum unloading was autonomously performed during the slew to the burn attitude, resulting in the thrusters being disarmed and disabled after the event by the flight software. At burn start minus one second, the thrusters are armed and the maneuver type flag is set for a thruster burn.

At the desired burn start time, the flight software is commanded from the ISH attitude control mode to the maneuver mode. In this mode, the flight software maneuver task will fire the selected delta V thrusters in an off-pulse mode to initiate the burn. The other thrusters are fired in an on-pulse mode to maintain the spacecraft within the pre-selected position and rate thresholds. The reaction wheels are maintained in tach hold throughout the duration of the burn. The maneuver task will terminate the maneuver when either the desired delta V has been achieved, the backup maximum burn cutoff time occurs, or one of the maneuver abort criteria is met. Upon maneuver termination, the IMU is commanded back to all gyro format and attitude control is transitioned back to the ISH mode, with reaction wheel control resumed after at least 30 seconds to damp rates on thrusters.

After the backup maximum maneuver duration time, the block (as implemented by on-board scripts) resumes execution. The frozen gyro check is disabled and the thrusters are disarmed and disabled. The spacecraft is next commanded back to the ANS attitude control mode, in which the spacecraft is slewed to align the spacecraft $+X_b$ axis along the Earth line (as determined from the on-board planetary ephemeris) and upon target acquisition, rotated about the X axis at 0.01 rpm.

After initiation of the slew, the solar arrays are commanded back to their cruise positions (i.e., canted 30° towards the spacecraft $+X_b$ axis).

The TWTA is next turned back on along with the Exciter. After allowing sufficient time for real-time engineering downlink for acquisition of the signal by the DSN and to determine the health status of the spacecraft, the recorder is played back at the 21.333 ksps playback rate, if this option is selected. After completion of the playback, the XSU is reconfigured for real-time engineering 2 kbps downlink again. An option exists in the block to playback the recorder a second time if sufficient time is available in the orbit.

If the battery management option was selected going into the ABM, after the desired battery recharge time, typically 80 minutes at the 7.5 A charge rate, the batteries are disconnected from the BCR and connected back to the alternate trickle charge circuit.

4.6.2 Constraints

1. The required flight software maneuver parameters (e.g., delta V, maximum maneuver duration, target quaternion), must be loaded via the MANLOAD block or an alternative ground procedure prior to execution of this ABM block.

2. If the TES is powered on prior to a maneuver, the block TES shall first be executed to safe the instrument.

3. The +Yb and -Yb solar array gimbal drives must be powered on and their redundancy management enabled prior to execution of this block. The panels must be oriented to provide proper center of mass control; positioning against the hard stops provides this control and is therefore selected. The soft stops must be disabled outside this block in order to allow the panels to reach the hard stops.

4. Latch valves LV2 and/or LV3 (depending on which string[s] are selected for the burn) must be open to allow hydrazine flow to the thrusters. LV2 and LV3 are not opened by this block.

5. The parameter SLEW_DUR must be set greater than or equal to the greatest of the four times required for: a) the solar panels to move to their desired positions before the burn, b) the spacecraft to turn to the desired attitude before the burn, c) the solar panels to move to their desired positions after the burn, and d) the spacecraft to turn to the desired attitude after the burn.

6. The IMU shall be in high rate mode.

7. The EDF is in engineering mode and the XSU is in 2kbps rate.

8. The appropriate maneuver PID gains to be used for the ABMs shall be pre-loaded prior to execution of this block.

9. The appropriate maneuver position and rate abort thresholds to be used for the ABMs shall be pre-loaded prior to execution of the block.

10. The block sets the nominal Actuator Select Flag to thrusters for the drag pass and to reaction wheels for the remainder of the orbit. The block maintains wheel speeds at their current values during maneuver execution. The block assumes the contingency Actuator Select Flag is set to thruster control prior to execution of this block, since Contingency Mode must be executed on thrusters during aerobraking.

11. In the event of a hydrazine half string latchout due to a leaking thruster, the thruster configuration flag shall be set designating which string is to be used, prior to execution of this block. The thruster side selection in the block should be consistent with the flight software knowledge of which side is enabled (String Utilization Flag).

12. An appropriate maneuver abort Contingency Mode cleanup script must be on-board and enabled prior to execution of this block.

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, before initiating the burn. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes. Late in aerobraking if power becomes a constraint, the warmup time may be reduced to 20 minutes, but only if both catbed heater strings are enabled. The thrusters are only qualified for 60 cold starts (cold start being defined as an initial catalyst temperature of < 150°F.
1.2	TWTA_OFF	INPUT	OFF	hh:mm:ss	00:05:00 - 01:00:00	00:12:30	Offset time from beginning of the maneuver to either turn the transmitter off or switch to the LGA for downlink.
1.3	TWTA_ON	INPUT	OFF	hh:mm:ss	00:05:00 - 01:00:00	00:12:30	Offset time from end of the maneuver to either turn the transmitter back or switch back to the HGA.
1.4	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:05:00 - 00:20:00	00:10:00	Maximum expected slew time to turn the spacecraft 180°.
1.5	REA_SELECT	INPUT	CHAR	N/A	BOTH EVEN ODD	BOTH	Selects desired REA thruster configuration to be used for the maneuver. Normally set to BOTH, to utilize both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be enabled for the drag pass.
1.6	EXCITER_OFF	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag set to power off the MOT Exciter during the ABM maneuver. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired to power off the Exciter during the maneuver when comm is unavailable. For larger orbits, unnecessary Exciter power cycling is undesirable.
1.7	SAP_AZ_BURN	INPUT	REAL	radians	-3.6652 to 2.6180	-0.22689	Parameter used to set +Y outer gimbal position for the burn. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft -Z axis.
1.8	SAP_EL_BURN	INPUT	REAL	radians	-3.6652 to 2.6180	-1.5708	Parameter used to set +Y inner gimbal position for the burn. Default value is set to 0 deg, facing the cells aft toward the spacecraft -Z axis.

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition
1.9	SAM_AZ_BURN	INPUT	REAL	radians	-2.6180 to 3.6652	0.0	Parameter used to set -Y outer gimbal position for the burn. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft -Z axis.
1.10	SAM_EL_BURN	INPUT	REAL	radians	-2.6180 to 3.6652	-1.62316	Parameter used to set -Y inner gimbal position for the burn. Default value is set to 0 deg, facing the cells aft toward the spacecraft -Z axis.
1.11	SAP_AZ_ANS	INPUT	REAL	radians	-3.6652 to 2.6180	-0.589048	Parameter used to set +Y outer gimbal position for the post-burn ANS attitude. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft +X axis. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired not to cant the solar array 30 degrees towards the spacecraft +X axis, but to leave it normal to the +X axis (0.0 degrees) to allow more solar illumination on the panels.
1.12	SAP_EL_ANS	INPUT	REAL	radians	-3.6652 to 2.6180	-1.570796	Parameter used to set +Y inner gimbal position for the post-burn ANS attitude. Default value is set to -90 deg, facing the cells toward the spacecraft +X axis.
1.13	SAM_AZ_ANS	INPUT	REAL	radians	-2.6180 to 3.6652	-0.23126	Parameter used to set -Y outer gimbal position for the post-burn ANS attitude. Default value is set to -30 deg, canting the array 30 degrees towards the spacecraft +X axis. For the small orbits (periods less than 3 hours), when SA power availability is a constraint, it may be desired not to cant the solar array 30 degrees towards the spacecraft +X axis, but to leave it normal to the +X axis (0.0 degrees) to allow more solar illumination on the panels.
1.14	SAM_EL_ANS	INPUT	REAL	radians	-2.6180 to 3.6652	1.570796	Parameter used to set -Y inner gimbal position for the post-burn ANS attitude. Default value is set to +90 deg, facing the cells toward the spacecraft +X axis.

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition
1.15	REC_SEL	INPUT	CHAR	N/A	REC_1A REC_1B REC_2A REC_2B NA	REC_1A	Parameter used to select the desired recorder for recording the ABM events. If REC_SEL is set to NA, then the record/playback option is not selected.
1.16	PB1_DELAY	INPUT	DUR	hh:mm:ss	00:02:10 - 24:00:00	01:00:00	After reacquiring Earth pointing, the amount of time allocated to real-time 2 kbps engineering downlink, before playing back the engineering telemetry recorded on the recorder. Set if REC_SEL is not equal to NA.
1.17	SECND_PB	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to specify a second (redundant) playback of the recorded engineering on the recorder, if sufficient time available in the orbit. Set if REC_SEL is not equal to NA.
1.18	PB2_DELAY	INPUT	DUR	hh:mm:ss	00:00:10 - 24:00:00	00:00:10	The delay time from completion of the first recorder playback until the start of the second redundant playback, if the second playback option is selected, Parameter No. 1.18 SECND_PB is set to TRUE. Typically, this parameter shall be set to allow the 2nd playback over a different DSN station and not to occur within the aerobraking drag pass window.
1.19	EDF_SIDE	INPUT	CHAR	N/A	EDF_1 EDF_2	EDF_1	Parameter used to specify which side of the EDF is on and sending telemetry to the recorder for recording.
1.20	BACKUP_DUR	INPUT	DUR	hh:mm:ss	N/A	N/A	The time from initiation of the burn for the block to resume control and command the spacecraft back to its nominal configuration. The value of BACKUP_DUR must be at least 5 seconds greater than the maximum value of the flight software maximum burn time (Parameter 2.4 MAX_DUR), to allow the maneuver task time to complete post-burn activities. Typically, BACKUP_DUR will be set to 5 seconds longer than the *largest possible* ABM burn in the current phase of aerobraking.

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition
1.21	BATT_CONFIG	INPUT	CHAR	N/A	BCR N/A	BCR	Option used to connect the batteries to the BCR prior to the ABM, to allow the batteries to be recharged at the higher BCR rates upon completion of the ABM. After sufficient recharge time (Parameter 1.22 BCR_DUR), the batteries are disconnected from the BCR and connected to the 0.18A trickle charger. This option is to be used throughout aerobraking until the orbit period reaches approximately two hours.
1.22	BCR_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 03:00:00	02:00:00	Desired duration to leave the batteries connected to the BCR for recharging at the higher BCR rates upon ANS reacquisition after the ABM. This duration shall be set sufficiently long to ensure the batteries are fully charged but not so long as to overcharge/overheat the batteries. Two hours is the predicted default value for this parameter.
1.23	BCR_SIDE	INPUT	CHAR	N/A	BCR_1 BCR_2	BCR_1	Parameter used to determine which BCR is currently in use, either the primary or backup, when reconnecting the batteries to the BCR for the drag pass.
1.24	BATT_STATUS	INPUT	CHAR	N/A	BOTH_OK BAT1_OK BAT2_OK	BOTH_OK	Parameter used to determine the operational status of the batteries when connecting and disconnecting the batteries from the BCR.
2.0	BURN_START	PDB (OPTG)	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired burn start time. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
2.1	BURN_QUAT	PDB (MNVR)	REAL(4)	N/A	N/A	N/A	The quaternion representing the desired burn attitude for the maneuver.
2.2	DELTA_V	PDB (MNVR)	REAL	m/sec	N/A	N/A	Desired delta V magnitude for the maneuver.
2.3	MIN_DUR	PDB (MNVR)	REAL	sec	N/A	N/A	The minimum burn duration. The maneuver will be allowed to continue to at least the value of MIN_DUR in the event of an accelerometer failure.

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition
2.4	MAX_DUR	PDB (MNVR)	REAL	sec	N/A	N/A	The backup maximum burn duration. In the event of an accelerometer failure the burn will be terminated when the backup timer equals MAX_DUR.
3.0	REA_ODD	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the odd string of 4.4 N engines (1,3,5,7,9,12) are to be enabled and armed for the maneuver calculated from the REA thruster configuration selection, Parameter No. 1.5 REA_SELECT. IF (REA_SELECT = BOTH OR ODD) THEN REA_ODD = TRUE
3.1	REA_EVEN	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the B string of 4.4 N engines (2,4,6,8,10,11) are to be enabled and armed for the maneuver, calculated from the REA thruster configuration selection, Parameter No. 1.5 REA_SELECT. IF (REA_SELECT = BOTH OR EVEN) THEN REA_EVEN = TRUE
3.2	PB_DUR	CALC	DUR	hh:mm:ss		N/A	The required time to playback the recorded 2 kbps engineering telemetry stream on the recorder. Calculated from the total time the transmitter was turned off. Assuming a 21.333 ksps playback rate: PB_DUR = (BACKUP_DUR + 00:35:00+ TWTA_ON + 00:03:00) / 10.666

Parameter Table (ABM)

No	Name	Source	Type	Units	Range	Default	Definition

3.3	PATH_SEL	CALC	CHAR	N/A	BOTH_PRI
					BAT1_PRI
					BAT2_PRI
					BOTH_BUP
					BAT1_BUP
					BAT2_BUP
						N/A	Parameter used to select the correct charge path when reconnecting the batteries to the BCR. Calculated from the battery and BCR status parameters, Params 1.24 and 1.23 respectively.
							
							IF (BCR_SIDE = BCR_1) THEN
							IF (BATT_STATUS = BOTH_OK) THEN
							PATH_SEL = BOTH_PRI
							ELSE IF (BATT_STATUS = BAT1_OK) THEN
							PATH_SEL = BAT1_PRI
							ELSE IF (BATT_STATUS = BAT2_OK) THEN
							PATH_SEL = BAT2_PRI
							ELSE
							IF (BATT_STATUS = BOTH_OK) THEN
							PATH_SEL = BOTH_BUP
							ELSE IF (BATT_STATUS = BAT1_OK) THEN
							PATH_SEL = BAT1_BUP
							ELSE IF (BATT_STATUS = BAT2_OK) THEN
							PATH_SEL = BAT2_BUP
							END IF

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of aerobrake maneuver (ABM) block execution.
2.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), nominally 30 min prior to the burn.
2.0.1	enable REA & catbed heater no 1		PRC01E	T = BURN_START - CATBED_DUR - 00:00:01	
2.0.2	enable REA & catbed heater no 3		PRC03E		
2.0.3	enable REA & catbed heater no 5		PRC05E		
2.0.4	enable REA & catbed heater no 7		PRC07E		
2.0.5	enable REA & catbed heater no 9		PRC09E		
2.0.6	enable REA & catbed heater no 12		PRC12E		
2.1	END IF		TEST		
2.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) nominally 30 min prior to the burn.
2.2.1	enable REA & catbed heater no 2		PRC02E	T = BURN_START - CATBED_DUR	
2.2.2	enable REA & catbed heater no 4		PRC04E		
2.2.3	enable REA & catbed heater no 6		PRC06E		
2.2.4	enable REA & catbed heater no 8		PRC08E		
2.2.5	enable REA & catbed heater no 10		PRC10E		
2.2.6	enable REA & catbed heater no 11		PRC11E		
2.3	END IF		TEST		

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0	IF (REC_SEL ≠ NA) THEN				
3.0.1	clear partitions on selected recorder recorder = REC_SEL mode = clear partitions		STSSRC	T = BURN_START - 00:35:02	Clear partitions on selected recorder prior to recording.
3.0.2	begin recording on selected recorder recorder = REC_SEL clock = EDF_SIDE mode = record partition = 1		STSSRC	T = BURN_START - 00:35:01	Begin recording 2 kbps engineering telemetry from the EDF on partition 1 of the desired recorder.
3.0.3	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = BURN_START - 00:35:00	Enable selected recorder to receive telemetry for recording.
3.1	END IF		TEST		
4.0	turn TWTA beam off		STRPAF	T = BURN_START - TWTA_OFF	Turn off TWTA beam.
4.1	IF (EXCITER_OFF = TRUE) THEN		TEST		
4.1.1	turn MOT exciter off		STMOTF		Option to turn off the Exciter for power conservation, at the expense of the potential adverse effects resulting from power cycling the component.
4.2	END IF		TEST		

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	IF (BATT_CONFIG = BCR) THEN		TEST		Until the orbit period has decreased to 2 hours, the battery configuration option must be selected to connect the batteries to the BCR prior to each ABM discharge period. After sufficient recharge time upon returning to ANS after the ABM (typically 45 min) the batteries are disconnected from the BCR and connected to the alternate .18A trickle charge circuit.
5.0.1	turn off 0.18 A alternate trickle charge circuit to both batteries		PWB1TF PWB2TF	T = BURN_START - SLEW_DUR - 00:03:03	Disconnect both batteries from alternate trickle charge path.
5.0.2	disable 0.18 A alternate trickle charge circuit to both batteries		PWB1TX PWB2TX	T = BURN_START - SLEW_DUR - 00:03:02	Disable the alternate trickle charge circuit to both batteries.
5.0.3	set BCR charge rate to 7.5 A battery select = BATT_STATUS		SWBCRS	T = BURN_START - SLEW_DUR - 00:03:01	Set the BCR to the 7.5 A charge rate for recharge after the ABM.
5.0.4	connect batteries to BCR charge_path_select = PATH_SEL		SWCHPS	T = BURN_START - SLEW_DUR - 00:03:00	Connect batteries to the BCR.
5.1	END IF		TEST		
6.0	load ISH control parameters slew rate = 0.0		SALICP	T = BURN_START - SLEW_DUR - 00:02:03	Load the ISH control mode parameters for the desired pitch rate. The ISH/pitch option is not utilized for the ABMs, so the pitch rate is set to zero.
6.1	load ISH control parameters quaternion = BURN_QUAT		SALICP	T = BURN_START - SLEW_DUR - 00:02:02	Load the ISH control mode parameters for the final desired attitude.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.2	load required delta V magnitude DELTA_V		SMDELV	T = BURN_START - SLEW_DUR - 00:02:01	Load the desired delta V for the maneuver. The maneuver task will calculate delta V to go using the accelerometers and terminate the maneuver when equal to zero.
6.3	load minimum maneuver time MIN_DUR		SMDMIN	T = BURN_START - SLEW_DUR - 00:02:01	Load the minimum burn duration for the maneuver. In the event of an accelerometer failure, the maneuver duration is controlled by a backup timer. Regardless of what the accelerometers measure, the maneuver will continue until at least the ground loaded minimum burn duration.
6.4	load maximum maneuver time MAX_DUR		SMDMAX		Load the maximum burn duration for the maneuver. Regardless of what the accelerometers measure, the maneuver will terminate no later than the ground loaded maximum burn duration.
6.5	set attitude control state to ISH		SAGISH	T = BURN_START - SLEW_DUR - 00:02:00	Attitude control software will slew to the desired attitude loaded in Event No. 6.1, using the reaction wheels. Worst case slew time for a 180 deg turn is about 10 minutes including wheel ramp up and ramp down. In ISH mode, nominal momentum unloading is disabled, although emergency unloading is available. Additionally in ISH mode, star processing is disabled.
7.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_BURN inboard gimbal angle = SAP_EL_BURN		SALPTA	T = BURN_START - SLEW_DUR - 00:01:03	Load the +Y SA azimuth and elevation gimbal target angles for the desired burn orientation.
7.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_BURN inboard gimbal angle = SAM_EL_BURN		SALMTA	T = BURN_START - SLEW_DUR - 00:01:02	Load the -Y SA azimuth and elevation gimbal target angles for the desired burn orientation.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.2	enable +Yb solar array manual gimbal drive rate control		SAPRCE	T = BURN_START - SLEW_DUR - 00:01:00	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the inboard and outboard gimbals will move to the target angles loaded in Events 7.0 and 7.1 at the times the target angles are loaded.
7.3	enable -Yb solar array manual gimbal drive rate control		SAMRCE		
8.0	switch IMU to accelerometer output format		SRACCF	T = BURN_START - 00:02:01	The IMU will be switched to the accelerometer output format prior to the start of the maneuver. The IMU must be in this mode in order for the flight software maneuver task to process accelerometer telemetry in order to determine delta V accumulation and the maneuver cutoff time.
8.1	enable frozen gyro check		SAFIME	T = BURN_START - 00:02:01	While the IMU is in the accelerometer output format, in which the 6 gyro co-channel compare ability is not available, the IMU is susceptible to a frozen gyro. Thus the frozen gyro check is enabled, allowing REDMAN to select the backup gyro axis if the gyro output remains identical for a selected number of consecutive cycles.
8.2	perform accelerometer null bias measurement		SMMACB	T = BURN_START - 00:02:00	The accelerometer bias measurement is initiated to measure the accelerometer output for a desired time (nominally 100 sec) during a quiescent period prior to the start of the maneuver, in order to determine the accelerometer biases.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
9.0	IF (REA_ODD) THEN		TEST		Re-enable the selected 4.4 N thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off.
9.0.1	enable REA & catbed heater no 1		PRC01E	T = BURN_START - 00:00:03	
9.0.2	enable REA & catbed heater no 3		PRC03E		
9.0.3	enable REA & catbed heater no 5		PRC05E		
9.0.4	enable REA & catbed heater no 7		PRC07E		
9.0.5	enable REA & catbed heater no 9		PRC09E		
9.0.6	enable REA & catbed heater no 12		PRC12E		
9.0.7	arm REAs 1,3,5,7,9,12		PRTHOA	T = BURN_START - 00:00:01	
9.1	END IF		TEST		
9.2	IF (REA_EVEN) THEN		TEST		
9.2.1	enable REA & catbed heater no 2		PRC02E	T = BURN_START - 00:00:02	
9.2.2	enable REA & catbed heater no 4		PRC04E		
9.2.3	enable REA & catbed heater no 6		PRC06E		
9.2.4	enable REA & catbed heater no 8		PRC08E		
9.2.5	enable REA & catbed heater no 10		PRC10E		
9.2.6	enable REA & catbed heater no 11		PRC11E		
9.2.7	arm REAs 2,4,6,8,10,11		PRTHEA	T = BURN_START - 00:00:01	
9.3	END IF		TEST		

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
10.0	set maneuver configuration flag to thrusters		SMTHDV	T= BURN_START - 00:00:01	Set the maneuver configuration flag to thrusters, to enable an RCS thruster burn
11.0	set aacs control state to maneuver		SMEXEC	T= BURN_START	The flight software will be commanded to the maneuver control state, to begin the maneuver.
11.1	set nominal actuator select flag to thruster control		SAASFT		Attitude control is maintained by mass expulsion during maneuvers. During aerobraking, Contingency Mode must be performed on thrusters, so the contingency actuator select flag must be set to thruster control prior to execution of this block.
11.2	*fire delta V thrusters*		*FSW*	*Performance*	*The flight s/w will begin firing the selected ΔV thrusters to initiate the burn. During the maneuver, the flight software will control the spacecraft attitude to the commanded inertial attitude with the thrusters. Reaction wheel speed will be controlled to the current speed. The task uses the thruster string(s) designated by the String Utilization Flag.*
11.3	*end maneuver; close thruster valves*		*FSW*	*Performance*	*The maneuver task will autonomously end the maneuver when either the desired delta V has been achieved, the backup maximum burn cutoff time occurs, or one of the maneuver abort criteria is met. The flight software will abort the maneuver if the unfiltered indicated body rates exceed 0.4 °/sec or the sun ephemeris monitor test indicates an excessive error between the predicted and measured sun angle. The maneuver task will transition to the ISH (non-maneuver) state upon completion of the burn.*
11.4	*switch IMU to all gyro format*		*FSW*	*Performance*	*The maneuver task autonomously switches the IMU back to all gyro format.*

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
12.0	disable frozen gyro check		SAFIMX	T= BURN_START + BACKUP_DUR	
13.0	set nominal actuator select flag to RWA control		SAASFW	T= BURN_START + BACKUP_DUR + 00:00:30	Return attitude control to reaction wheels after the maneuver. Thirty seconds are allocated for settling time.
14.0	disarm REAs 1,3,5,7,9,12		PRTHOD	T= BURN_START + BACKUP_DUR + 00:00:31	Disarm thrusters after switching to reaction wheel control.
14.1	disarm REAs 2,4,6,8,10,11		PRTHED		
14.2	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= BURN_START + BACKUP_DUR + 00:00:32	Disable thrusters after switching to reaction wheel control.
14.3	disable REAs & catbed heaters no 2,4,6		PRCTBX		
14.4	disable REAs & catbed heaters no 7,9,12		PRCTCX		
14.5	disable REAs & catbed heaters no 8,10,11		PRCTDX		
15.0	set attitude control state to array normal spin (ANS)		SAGANS	T= BURN_START + BACKUP_DUR + 00:00:34	Command back to normal cruise ANS attitude control mode upon completion of the burn (+X axis aligned with the ephemeris generated earth vector).
16.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_ANS inboard gimbal angle = SAP_EL_ANS		SALPTA	T= BURN_START + BACKUP_DUR + 00:01:29	Load the desired gimbal target angles for the inboard and outboard gimbals of the +Yb mounted solar array, to orient the array back to its cruise position.
16.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_ANS inboard gimbal angle = SAM_EL_ANS		SALMTA	T= BURN_START + BACKUP_DUR + 00:01:30	Load the desired gimbal target angles for the inboard and outboard gimbals of the -Yb mounted solar array, to orient the array back to its cruise position.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
17.0	turn TWTA beam on		STRPAN	T = BURN_START + BACKUP_DUR + TWTA_ON	Turn the TWTA back on after the maneuver. This command also turns the MOT Exciter on if it had been turned off during the maneuver for power conservation.
18.0	IF (REC_SEL ≠ NA) THEN		TEST		Begin playback of recorded telemetry if record/playback option selected.
18.0.1	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = BURN_START + BACKUP_DUR + TWTA_ON + 00:02:00	Disable selected recorder from recording (i.e., set to standby).
18.0.2	set XSU mode for playback from selected recorder source = REC_SEL		STMOTC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY - 00:00:02	Configure the XSU to send the telemetry from the selected recorder to the MOT.
18.0.3	IF (REC_SEL = REC_2B) THEN		STATE		
18.0.3.1	configure recorder 2B's clock prior to playback recorder = rec 2A clock = 21_KHz mode = enable scrub partition = 1		STSSRC		The 2B recorder must use the 2A recorder clock to perform telemetry playback due to a heritage idiosyncracy in the XSU to recorder interface design.
18.0.3.2	END IF		TEST		
18.0.4	begin playback from selected recorder recorder = REC_SEL clock = 21_KHz mode = playback partition = 1		STSSRC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY - 00:00:01	Begin playback at the selected playback rate from partition 1 of the selected recorder.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
18.0.5	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY	Enable selected recorder for playback.
18.0.6	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR	Disable selected recorder from playing back (i.e., set to standby).
18.0.7	set XSU mode for EDF real-time transmission source = EDF_SIDE		STMOTC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + 00:00:01	
18.0.8	IF (SECND_PB) THEN		TEST		If orbital period is large enough, perform a second redundant playback of the recorded maneuver telemetry.
18.0.8.1	set selected recorder to enable scrub recorder = REC_SEL clock = 21_KHz mode = enable scrub partition = 1		STSSRC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:03	Prior to performing redundant playback, the SSR state must be reset to something other than playback (i.e., enable scrub) in order for the playback command to work.
18.0.8.2	set XSU mode for playback from selected recorder bits 4-7 set to REC_SEL		STMOTC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:02	Configure the XSU to send the telemetry from the selected recorder to the MOT.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
18.0.8.3	IF (REC_SEL = REC_2B) THEN		STATE		
18.0.8.3.1	configure recorder 2B's clock prior to playback recorder = rec 2A clock = 21_KHz mode = enable scrub partition = 1		STSSRC		The 2B recorder must use the 2A recorder clock to perform telemetry playback due to a heritage idiosyncracy in the XSU to recorder interface design.
18.0.8.4	END IF		TEST		
18.0.8.5	begin playback from selected recorder recorder = REC_SEL clock = 21_KHz mode = playback partition = 1		STSSRC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY - 00:00:01	Begin playback at selected playback rate from partition 1 of the selected recorder.
18.0.8.6	enable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AE CSD1BE CSD2AE CSD2BE	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY	Enable recorder 1A for playback.
18.0.8.7	disable data on selected recorder	REC_1A REC_1B REC_2A REC_2B	CSD1AX CSD1BX CSD2AX CSD2BX	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR	Disable recorder 1A from playing back (i.e., set to standby).

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
18.0.8.8	set XSU mode for EDF real-time transmission bits 4-7 set to EDF_SIDE		STMOTC	T = BURN_START + BACKUP_DUR + TWTA_ON + PB1_DELAY + PB_DUR + PB2_DELAY + PB_DUR + 00:00:01	
18.0.9	END IF (SECND_PB)		TEST		
18.1	END IF (REC_SEL ≠ NA)		TEST		
19.0	IF (BATT_CONFIG = BCR) THEN		TEST		Until the orbit period has decreased to 2 hours, the battery configuration option must be selected to connect the batteries to the BCR prior to each ABM discharge period (i.e. when initial slew off of ANS is performed). After sufficient recharge time upon returning to ANS after the ABM (typically 45 min) the batteries are disconnected from the BCR and connected to the alternate .18A trickle charge circuit.
19.0.1	disconnect both batteries from the BCR address = h2464 dataword value = h8440		SISERC	T = BURN_START - SLEW_DUR - 00:03:00 + BCR_DUR	Disconnect both batteries from the BCR.
19.0.2	enable 0.18 A alternate trickle charge circuit to both batteries		PWB1TE PWB2TE	T = BURN_START - SLEW_DUR - 00:03:00 + BCR_DUR + 00:00:01	Enable the alternate trickle charge circuit to both batteries.

Event Table (ABM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
19.0.3	turn on 0.18 A alternate trickle charge circuit to both batteries		PWB1TN PWB2TN	T = BURN_START - SLEW_DUR - 00:03:00 + BCR_DUR + 00:00:02	Connect both batteries from alternate trickle charge path.
19.1	END IF		TEST		
20.0	END BLOCK		STATE		Completion of ABM block execution.

State Table (ABM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	ANS	ISH » ISH/Maneuver » ISH	ANS
	Actuator Select Flag	RWAs	Thrusters	RWAs
	Local Vertical Offset Flag	Enabled		Enabled
	Local Vertical Offset Quaternion	(0.0, 0.707106781, 0.0, 0.707106781)		(0.0, 0.707106781, 0.0, 0.707106781)
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)	Accelerometer (3 gyro channels, 3 accelerometer channels)	All Gyro (6 gyro channels)
	IMU Rate Mode	High Rate Mode		High Rate Mode
	IMU Frozen Gyro Check	Disabled	Enabled	Disabled
	Star Processing	Enabled	Disabled in ISH (autonomous function)	Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)	RWAs in Tach Hold Mode during Burn (autonomous function)	3 On, 1 Off (normally skew wheel)
	MHSA Power State	Off		Off
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On		On
	HGA GDE Power State / Control Mode	Off		Off
	HGA GDE Control Mode	Disabled		Disabled
	Sun Avoidance	Enabled		Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled

State Table (ABM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH				
	EDF Mode	Engineering Mode (2 Kbps Telemetry Rate)		Engineering Mode (2 kbps Telemetry Rate)
	XSU Mode	EDF Telemetry to MOT for Real-time Downlink PDS Telemetry to SSR for Recording during MAG Data Collection Period of Aerobraking	EDF Telemetry to SSR for Recording » SSR Telemetry to MOT for Playback » EDF Telemetry to MOT for Real-time Downlink » SSR Telemetry to MOT for Optional second Playback	EDF Telemetry to MOT for Real-time Downlink PDS Telemetry to SSR for Recording during MAG Data Collection Period of Aerobraking
	SSR Power State / Mode	1 Recorder On / Standby Additional Recorder On / Recording PDS Telemetry during MAG Data Collection Period of Aerobraking	Record EDF Telemetry » Playback (21 kbps) » Standby » Optional second Playback(21 kbps)	1 Recorder On / Standby Additional Recorder On / Recording PDS Telemetry during MAG Data Collection Period of Aerobraking
	PDS Power State / Mode	On / LRC (Low Rate Record - 4 Ksps) during MAG Data Collection Period of Aerobraking		On / LRC (Low Rate Record - 4 Ksps) during MAG Data Collection Period of Aerobraking
Propulsion				
	Note NC = Normally Closed NO = Normally Open			
	Helium Pressurant Latch Valve 1 & Redundant Pyro Valve 1 (NC)	Opened Not Fired unless LV 1 fails closed		Opened Not Fired unless LV 1 fails closed
	RCS thruster Latch Valves 2 & 3	Both Open unless leaky thruster detected		Both Open unless leaky thruster detected
	Main Engine Latch Valves 4 & 5 & Redundant Pyro Valves 13 & 14 (NC)	Closed Not fired unless LV4 or LV5 fail closed		Closed Not fired unless LV4 or LV5 fail closed

State Table (ABM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Propulsion (continued)	Pressurant Isolation Pyro Valves 2 through 6	PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Regulator Isolation Pyro Valves 7 through 9	PV 7 (NO) Not Fired unless Primary Regulator leak detected PV 8 (NC) Not Fired unless Backup Regulator brought on line PV 9 (NC) Not Fired unless Backup Regulator brought on line		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Oxidizer Isolation Pyro Valves 10 through 12	PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required		PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required
	Main Engine	Disabled and Disarmed		Disabled and Disarmed
	RCS Thrusters odd string (1,3,5,7,9,12) even string (2,4,6,8,10,11)	 Disabled and Disarmed Disabled and Disarmed	 Both Strings Enabled and Armed (unless a string latched out due to leaky thruster)	 Disabled and Disarmed Disabled and Disarmed

State Table (ABM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Thermal				
	Main Engine Injector Heaters	Off		Off
	RCS Thruster Catbed Heaters * odd string (1,3,5,7,9,12) even string (2,4,6,8,10,11)	Off Off	Both Strings On (unless a string latched out due to leaky thruster)	Off Off
	* Note that each thruster has its own catbed heater, turned on when the thruster is enabled			
Telecom				
	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna	HGA		HGA
	TWTA 1 Filament	Off		Off
	TWTA 1 Beam	Off		Off
	TWTA 2 Filament	On		On
	TWTA 2 Beam	On	Off	On
	MOT 1 Exciter	Off		Off
	MOT 2 Exciter	On	Off (if option selected)	On
	MOT Noncoherent Mode	Off		Off
	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	On		On
	MOT Ranging	On		On

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4.7 HGADPLY - High Gain Antenna Deployment Block

4.7.1 Block Description

This block is used to deploy the High Gain Antenna (HGA) after completing aerobraking. There are two parts to this block:
1) pre-deploy events through the release of the HGA, and
2) first gimbal motion through the return to ANS.
The second part is triggered by ground command after sufficient boom deploy motion is verified. The HGA boom must travel through a minimum of about 60° of arc before gimbal motion is initiated, in order to prevent damage to the HGA from contact with the boom.

This block is intended for use only once, and need not be coded into the sequencing software. It is included here for documentation purposes.

All events in the first part of the block are timed relative to the start of the deployment event.

The first event in the block is to warmup the catbed heaters of the thrusters to be used while under thruster control. Depending on the configuration of the propulsion system, the block has an option to use all twelve of the thrusters or, in the event of a half-side latch out, either the odd or even string of thrusters. Depending on the position of a ground-commandable relay, either the primary set of catbed heaters, or both the primary and secondary sets of catbed heaters will be used.

Next, the Low Gain Antenna is selected for both uplink and downlink, two-way non-coherent (TWNC) mode is turned on and telemetry modulation is turned off to maximize the length of time downlink carrier will be available during the deployment. The HGA is not selected at the end of this block because a calibration is expected to be necessary before HGA pointing will be sufficient for communications.

Attitude control is next commanded to the ISH mode to turn the spacecraft to the desired attitude under reaction wheel control. Autonomous sun avoidance protection remains enabled during the slew, thereby ensuring the payload will not be pointed within 30 degrees of the sun. The selected ISH attitude is expected to contain a spacecraft tilt "up" (a negative rotation about Y) of 40° to 60° such that the HGA deploy motion will maintain Earth in the LGA field of view (FOV) for the majority of the deployment arc. The LGA FOV is not large enough to maintain contact through the last approximately 75° of deployment arc.

The solar panels are then positioned to maximize power during the deployment. This action both ensures sufficient power to the burnwires and avoids battery usage should the deployment not proceed smoothly, requiring an extended stay in the ISH attitude. Only the elevation gimbal need move, but both the azimuth and elevation positions are set in the block.

The next event in the block is to turn on the unused skew reaction wheel assembly (RWA) if necessary. RWAs can be damaged by pyro events if not spinning at 200 rpm or greater. An input parameter in the block identifies whether the skew wheel is being used. If it is off, it is powered on by the block. If it is already on, one of the orthogonal wheels has probably failed and should not be turned on. If one of the orthogonal wheels had been turned off because it exhibited undesirable behavior but is worth preserving, it should be turned on by realtime command outside this block. Once the appropriate RWAs are powered, the Despin/Deploy AACS control state will hold all RWAs to a specified (parameter) constant speed.

Next, the thrusters are armed and the thruster configuration flag is set for the desired thruster configuration to be used for attitude control, according to the input flag selecting odd, even, or both strings.

Thruster control is selected and the AACS control state is set to Despin/Deploy for the pyro event.

The next event is to perform the deployment pyro event. The primary and secondary pyro buses are enabled and armed, the primary and secondary HGA deployment release pyros are fired, and the pyro buses are disarmed and disabled. Fifteen minutes are allocated for the HGA boom to complete its travel and latch, providing a 5 minute margin to the requirement to deploy and latch within 10 minutes under all conditions. At this point, telemetry modulation is turned back on and 10 bps is selected. The spacecraft is then slewed to Earthpoint and the solar panels repositioned to their ANS locations.

At this point attitude control is switched back to reaction wheels and the thrusters and catbed heaters disabled and disarmed. The skew wheel is then turned off (if it was turned on earlier) and a 10 minute delay is observed to allow telemetry from the skew wheel to be processed by the AACS flight software as it spins down. After the ten minute delay has completed, redundancy management is configured to the use the remaining three wheels. Without the REDMAN command, an unnecessary swapping of the CIU bus would occur in the event one of the three orthogonal wheels were to actually fail during the pyro firing activities, since REDMAN would believe there were two failed wheels instead of one when the skew wheel was turned off.

These activities conclude the first part of the block.

Upon confirmation that the boom has sufficiently deployed to allow gimbal motion to proceed safely, the ground will initiate the second part of the block. All events in the second part of the block are timed relative to first gimbal motion. Since the signal will disappear as the HGA is deployed, it may be desirable to swap to LGA 2 for downlink (using commands STRPAF, STLGT2, STRPAN) before issuing the trigger command for the second part of this block. Since LGA 2 is located on the back side of the HGA, downlink should be available once deployment progresses to a sufficient degree. Such commanding would be performed by the non-stored process outside the deployment sequence.

The first event in the second part of the block is to turn on the HGA gimbal drive electronics and set the HGA control state to off. HGA fault protection is enabled. The HGA is then positioned to earthpoint, one gimbal at a time. Because of geometric constraints, the azimuth (outboard) gimbal must be positioned first to avoid contact between the HGA and the boom. The elevation (inboard) gimbal is positioned second. Two minutes are allocated for each gimbal's motion.

Upon completion of the HGA positioning, the spacecraft is commanded back to ANS.

These activities conclude the second part of the block. After completion of the HGADPLY block events, the Mission Phase Relays will be set to Mapping by ground command.

4.7.2 Constraints

1. The block SSRMGR shall be executed in conjunction with this block to record engineering telemetry during the deployment event.

2. The HGA cable heaters must be activated and deactivated outside this block.

3. The initial AACS state is Array Normal Spin (ANS) and the block returns the AACS control mode to ANS.

4. The IMU must be in high rate mode.

5. The tach hold RWA speeds are set to the desired values for the deploy event within this block.

6. In the event of a hydrazine half string latchout due to a leaking thruster, the thruster configuration flag shall be set designating which string is to be used, prior to execution of this block. The thruster side selection in the block should be consistent with the flight software knowledge of which side is enabled (String Utilization Flag).

7. The command loss timer should be set to an appropriate value for this event, which may be shorter than the nominal value.

8. 70-meter downlink coverage is required to maintain carrier lock using the LGA during the deployment, due to the offpoint used to maximize visibility into the event. 34-meter HEF coverage is also needed to enable an X-band uplink.

9. TWNC must be turned off via non-block command after execution of this block. This delay ensures maximum visibility into the status of the deployment for as long as necessary.

10. Prior to execution of this block, the batteries shall be connected to the BCR to prevent a possible failure in which a single wire were to open due to the shock of firing the HGA boom burnwires, causing loss of control of the charge path select relays for the battery.

Parameter Table (HGADPLY)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	DPLY_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired start time to fire pyro initiators for the deployment event. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.1	GMBL_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired start time to begin gimbal movement after the deployment event. This time will be overwritten when the trigger command is developed.
1.2	S_RWA	INPUT	CHAR	N/A	'OFF' 'ON'	'OFF'	Parameter used to determine whether the skew RWA is currently powered off, and thus not being used for attitude control. This will ensure that the skew RWA is turned on during the block execution for safing during the pyro firing event, and turned off again when the event has been completed. If an orthogonal RWA had failed previously, the skew wheel will already be powered on and its will not be changed in this block. If an orthogonal RWA had previously behaved erratically and was shut off, but it is still desired to turn it on to safe it for the pyro firing event, then it must be powered on and off externally to this block.
1.3	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, prior to usage. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes.
1.4	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:05:00 - 00:20:00	00:07:00	Maximum expected slew duration to turn the spacecraft to the pyro firing attitude.
1.5	REA_SELECT	INPUT	CHAR	N/A	BOTH ODD EVEN	BOTH	Selects desired REA thruster configuration for control. Normally set to BOTH, to use both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be used.

Parameter Table (HGADPLY)

No	Name	Source	Type	Units	Range	Default	Definition
1.6	HGA_AZ_FNL	INPUT	REAL	radians	-1.7453 to 4.5379	0.0	Parameter used to set HGA azimuth (outboard) gimbal position after deployment.
1.7	HGA_EL_INIT	INPUT	REAL	radians	-3.1416 to 3.1416	-1.6581	Parameter used to set HGA elevation (inboard) gimbal to initial (pre-deployment) position. Ensures this gimbal will not move until after the azimuth gimbal is in final position. Set to actual measured value once known.??
1.8	HGA_EL_FNL	INPUT	REAL	radians	-3.1416 to 3.1416	-1.5708	Parameter used to set HGA elevation (inboard) gimbal to final position after the azimuth gimbal is in final position.
1.9	PYRO_QUAT	INPUT	REAL(4)	N/A	N/A	N/A	Parameter used to set the desired ISH mode inertial attitude quaternion for the pyro firing.
1.10	X_WHL_SPD_INIT	INPUT	INT	wcounts (1 wcount = 5 rpm)	-600 to 600	+40	Parameter used to set desired X RWA tach hold speed to be maintained during the pyro event.
1.11	Y_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	-40	Parameter used to set desired Y RWA tach hold speed to be maintained during the pyro event.
1.12	Z_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+40	Parameter used to set desired Z RWA tach hold speed to be maintained during the pyro event.
1.13	S_WHL_SPD_INIT	INPUT	INT	wcounts	-600 to 600	+69	Parameter used to set desired skew RWA tach hold speed to be maintained during the pyro event.
1.14	SAP_AZ_DPLY	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA azimuth gimbal angle to position the solar arrays for the deployment. The solar arrays are positioned for power optimization.
1.15	SAP_EL_DPLY	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA elevation gimbal angle to position the solar arrays for the deployment. The solar arrays are positioned for power optimization.
1.16	SAM_AZ_DPLY	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA azimuth gimbal angle to position the solar arrays for the deployment. The solar arrays are positioned for power optimization.

Parameter Table (HGADPLY)

No	Name	Source	Type	Units	Range	Default	Definition
1.17	SAM_EL_DPLY	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA elevation gimbal angle to position the solar arrays for the deployment. The solar arrays are positioned for power optimization.
1.18	POST_ QUAT	INPUT	REAL(4)	N/A	N/A	N/A	Parameter used to set the desired ISH mode inertial attitude quaternion after the pyro firing.
1.19	SAP_AZ_ANS	INPUT	REAL	rad	-3.6652 to 2.6180	-0.5236	Desired +Y SA azimuth gimbal angle for the post-deploy SA position (same as when the spacecraft is in the ANS attitude). Default value is set to -30°, to cant the solar array 30 degrees towards the spacecraft +X axis.
1.20	SAP_EL_ANS	INPUT	REAL	rad	-3.6652 to 2.6180	-1.5708	Desired +Y SA elevation gimbal angle for the post-deploy SA position (same as when the spacecraft is in the ANS attitude). Default value is set to -90°, placing the cells toward the spacecraft +X axis.
1.21	SAM_AZ_ANS	INPUT	REAL	rad	-2.6180 to 3.6652	-0.5236	Desired -Y SA azimuth gimbal angle for the post-burn SA position (same as when the spacecraft is in the ANS attitude). Default value is set to -30°, to cant the solar array 30 degrees towards the spacecraft +X axis.
1.22	SAM_EL_ANS	INPUT	REAL	rad	-2.6180 to 3.6652	1.5708	Desired -Y SA elevation gimbal angle for the post-deploy SA position (same as when the spacecraft is in the ANS attitude). Default value is set to +90°, placing the cells toward the spacecraft +X axis.

Parameter Table (HGADPLY)

No	Name	Source	Type	Units	Range	Default	Definition
1.24	MOD_INDEX	INPUT	CHAR	N/A	42.3_DEG 44.8_DEG 47.3_DEG 49.9_DEG 52.4_DEG 54.9_DEG 57.4_DEG 59.9_DEG	42.3_DEG	Parameter used to select the required modulation index for the 10 bps downlink data rate. The table lists the available modulation indices, the modulation voltage supplied to the MOT and the telemetry rates intended for use with the selected modulation index. MOD_INDEX / Amplitude (mV peak) / Intended Use 42.3_DEG 369 10 bps or 250 bps 44.8_DEG 391 10 bps or 250 bps 47.3_DEG 413 10 bps or 250 bps 49.9_DEG 435 10 bps or 250 bps 52.4_DEG 457 10 bps or 250 bps 54.9_DEG 479 10 bps or 250 bps 57.4_DEG 501 10 bps or 250 bps 59.9_DEG 523 10 bps or 250 bps Note that the XSU will automatically provide the required subcarrier frequency when the modulation index is set for the desired telemetry rate. For all mod indices listed in the table above, the subcarrier frequency selected will be 21.33 kHz.
1.25	XSU_STATUS	INPUT	CHAR	N/A	BOTH_OK XSU1_OK XSU2_OK	BOTH_OK	Parameter used to select the current operational status of XSU sides 1 and 2. If set to BOTH_OK, then XSU side 1 and XSU side 2 are both operational. If set to XSU1_OK, then XSU side 1 is operational and XSU side 2 has failed. If set to XSU2_OK, then XSU side 2 is operational and XSU side 1 has failed.
2.0							No PDB parameters for this block.
3.0	REA_ODD	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the odd string of thrusters (1,3,5,7,9,12) are to be enabled and armed, calculated from the REA thruster configuration selection, Parameter No. 1.5 REA_SELECT. IF (REA_SELECT = BOTH OR ODD) THEN REA_ODD = TRUE

Parameter Table (HGADPLY)

No	Name	Source	Type	Units	Range	Default	Definition
3.1	REA_EVEN	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the even string of thrusters (2,4,6,8,10,11) are to be enabled and armed, calculated from the REA thruster configuration selection, Parameter No. 1.5 REA_SELECT. IF (REA_SELECT = BOTH OR EVEN) THEN REA_EVEN = TRUE
3.2	XSU_1	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 1 as operational, when setting the modulation index for the desired subcarrier and telemetry rate. IF (XSU_STATUS = BOTH_OK OR XSU1_OK) THEN XSU_1 = TRUE ELSE XSU_1 = FALSE
3.3	XSU_2	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 2 as operational, when setting the modulation index for the desired subcarrier and telemetry rate. IF (XSU_STATUS = BOTH_OK OR XSU2_OK) THEN XSU_2 = TRUE ELSE XSU_2 = FALSE

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of HGADPLY block execution.
2.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), normally 30 min prior to usage.
2.0.1	enable REA & turn on catbed htr no 1		PRC01E	T = DPLY_START - CATBED_DUR - 00:00:01	
2.0.2	enable REA & turn on catbed htr no 3		PRC03E		
2.0.3	enable REA & turn on catbed htr no 5		PRC05E		
2.0.4	enable REA & turn on catbed htr no 7		PRC07E		
2.0.5	enable REA & turn on catbed htr no 9		PRC09E		
2.0.6	enable REA & turn on catbed htr no 12		PRC12E		
2.1	END IF		TEST		
2.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) normally 30 min prior to usage.
2.2.1	enable REA & turn on catbed htr no 2		PRC02E	T = DPLY_START - CATBED_DUR	
2.2.2	enable REA & turn on catbed htr no 4		PRC04E		
2.2.3	enable REA & turn on catbed htr no 6		PRC06E		
2.2.4	enable REA & turn on catbed htr no 8		PRC08E		
2.2.5	enable REA & turn on catbed htr no 10		PRC10E		
2.2.6	enable REA & turn on catbed htr no 11		PRC11E		
2.3	END IF		TEST		

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0	turn TWTA beam off		STRPAF	T= DPLY_START - SLEW_DUR - 00:09:09	Avoid hot switching antenna by turning off beam.
3.1	switch to LGA 1 for both transmit and receive		STLGT1 STLGR1	T= DPLY_START - SLEW_DUR - 00:09:04	Communications via the LGA are expected for most of the deployment event.
3.2	configure CDUs for 7.8125 uplink bit rate		TCC1BS TCC2BS	T= DPLY_START - SLEW_DUR - 00:09:03	Switch uplink rate to 7.8125 bps while communications are over the LGA.
3.3	turn telemetry modulation off	MOT_1 MOT_2	TCM1MF TCM2MF	T= DPLY_START - SLEW_DUR - 00:09:02	Telemetry modulation is turned off to increase the carrier strength by about 2.6 dB.
3.4	enable MOT non-coherent mode	MOT_1 MOT_2	TCM12E TCM22E	T= DPLY_START - SLEW_DUR - 00:09:01	Set MOT to non-coherent mode to increase the carrier strength by about 1 dB.
3.5	turn TWTA beam on		STRPAN	T= DPLY_START - SLEW_DUR - 00:09:00	Turn beam back on after telecom reconfiguration. Beam will turn on after 4 minutes to allow the filament to warm up. This will allow 5 minutes for the DSN to reacquire the signal (without telemetry modulation on), before the deployment begins.
4.0	load ISH control parameters rate = 0.0		SALICP	T= DPLY_START - SLEW_DUR - 00:02:02	The ISH pitch rate is set to zero.
4.1	load ISH control parameters quaternion = PYRO_QUAT		SALICP	T= DPLY_START - SLEW_DUR - 00:02:01	Load the quaternion for the desired initial inertial attitude for the pyro firing.
4.2	set attitude control state to inertial slew hold (ISH)		SAGISH	T= DPLY_START - SLEW_DUR - 00:02:00	Command the spacecraft to the ISH attitude control state. Attitude control software will slew to the desired pyro firing attitude, using the reaction wheels. The attitude will be selected to maximum visibility of the boom deployment.

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_DPLY inboard gimbal angle = SAP_EL_DPLY		SALPTA	T = DPLY_START - SLEW_DUR - 00:01:03	Load the +Y SA azimuth and elevation gimbal target angles for the desired deployment orientation.
5.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_DPLY inboard gimbal angle = SAM_EL_DPLY		SALMTA	T = DPLY_START - SLEW_DUR - 00:01:02	Load the -Y SA azimuth and elevation gimbal target angles for the desired deployment orientation.
5.2	enable +Yb and -Yb solar array manual gimbal drive rate control		SAPRCE SAMRCE	T = DPLY_START - SLEW_DUR - 00:01:00	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the inboard and outboard gimbals will move to the target angles loaded in Events 5.0 and 5.1 at the times the target angles are loaded.
6.0	IF (S_RWA = OFF) THEN		TEST	T = DPLY_START - 00:01:10	Only three RWAs (nominally the three orthogonal RWAs) are powered on for attitude control. If the skew wheel is powered off, it could potentially be damaged if it is not powered on and spinning during the pyro firing events. Thus it is turned on to safe it for the pyro firing event. If the skew wheel is already on, one of the orthogonal wheels has probably failed and should not be turned on. If one of the orthogonal wheels had been turned off because it exhibited undesirable behavior but is worth preserving, it should be turned on by realtime command outside this block.
6.0.1	turn on skew RWA		ARWASN		
6.1	END IF		TEST		

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0	IF (REA_ODD) THEN		TEST		Re-enable the selected thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off and the thrusters disarmed & disabled.
7.0.1	enable REA & catbed heater no 1		PRC01E	T= DPLY_START - 00:01:04	
7.0.2	enable REA & catbed heater no 3		PRC03E		
7.0.3	enable REA & catbed heater no 5		PRC05E		
7.0.4	enable REA & catbed heater no 7		PRC07E		
7.0.5	enable REA & catbed heater no 9		PRC09E		
7.0.6	enable REA & catbed heater no 12		PRC12E		
7.0.7	arm REAs 1,3,5,7,9,12		PRTHOA	T= DPLY_START - 00:01:02	
7.1	END IF		TEST		
7.2	IF (REA_EVEN) THEN		TEST		
7.2.1	enable REA & catbed heater no 2		PRC02E	T= DPLY_START - 00:01:03	
7.2.2	enable REA & catbed heater no 4		PRC04E		
7.2.3	enable REA & catbed heater no 6		PRC06E		
7.2.4	enable REA & catbed heater no 8		PRC08E		
7.2.5	enable REA & catbed heater no 10		PRC10E		
7.2.6	enable REA & catbed heater no 11		PRC11E		
7.2.7	arm REAs 2,4,6,8,10,11		PRTHEA	T= DPLY_START - 00:01:02	
7.3	END IF		TEST		

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.0	set nominal actuator select flag to thruster control		SAASFT	T= DPLY_START - 00:01:02	Transition to thruster control for the pyro firing.
8.1	set contingency actuator select flag to thruster control		SAACMT		
9.0	set tach hold wheel speed X_WHL_SPD_INIT Y_WHL_SPD_INIT Z_WHL_SPD_INIT S_WHL_SPD_INIT		SALFWS	T= DPLY_START - 00:01:01	Specify desired wheel speed to be maintained during the pyro event.
9.1	set AACS control state to despin/deploy		SAGDPL	T= DPLY_START - 00:01:00	The flight software will command all RWAs to hold constant at the selected speed.
10.0	enable primary and secondary mapping pyro bus		PYMPPE PYMPSE	T= DPLY_START - 00:00:04	
10.1	arm primary and secondary mapping pyro bus		PYMPPA PYMPSA	T= DPLY_START - 00:00:02	
10.2	fire first HGA release primary and secondary burnwires		PYHG1P PYHG1S	T= DPLY_START	
10.3	fire second HGA release primary and secondary burnwires		PYHG2P PYHG2S	T= DPLY_START + 00:00:01	
10.4	fire third HGA release primary and secondary burnwires		PYHG3P PYHG3S	T= DPLY_START + 00:00:02	
10.5	disarm primary and secondary mapping pyro bus		PYMPPD PYMPSD	T= DPLY_START + 00:00:04	
10.6	disable primary and secondary mapping pyro bus		PYMPPX PYMPSX	T= DPLY_START + 00:00:06	

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
11.0	set nominal actuator select flag to reaction wheel control		SAASFW	T= DPLY_START + 00:14:30	Return attitude control to reaction wheels after the deployment. Thirty seconds are allocated for settling time.
11.1	set contingency actuator select flag to reaction wheel control		SAACMW		
11.2	disarm REAs 1,3,5,7,9,12		PRTHOD	T= DPLY_START + 00:14:31	Disarm all of the REAs.
11.3	disarm REAs 2,4,6,8,10,11		PRTHED		
11.4	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= DPLY_START + 00:14:32	Disable all of the REAs and their catbed heaters.
11.5	disable REAs & catbed heaters no 2,4,6		PRCTBX		
11.6	disable REAs & catbed heaters no 7,9,12		PRCTCX		
11.7	disable REAs & catbed heaters no 8,10,11		PRCTDX		
12.0	load ISH control parameters quaternion = POST_QUAT		SALICP	T= DPLY_START + 00:14:59	Load the quaternion for the desired initial inertial attitude after the pyro firing.
12.1	set attitude control state to ISH		SAGISH	T= DPLY_START + 00:15:00	Begin the slew to the post-pyro firing attitude.
13.0	turn telemetry modulation on	MOT_1 MOT_2	TCM1MN TCM2MN	T= DPLY_START + 00:15:01	If HGA did not deploy, the next three actions restore telemetry visibility. If the HGA did deploy, these actions prepare the downlink path for telemetry transmission after the HGA gimbals are properly positioned in part 2 of this block. 1. Turn telemetry modulation on.
13.1	set EDF to emergency mode		SCEDFC	T= DPLY_START + 00:15:02	2. Select 10 bps rate.
13.2	set the modulation index for 10 bps data rate MOD_INDEX	XSU_1 XSU_2	CXSPG1 CXSPG2	T= DPLY_START + 00:15:03	3. Select mod index.

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
14.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_ANS inboard gimbal angle = SAP_EL_ANS		SALPTA	T = DPLY_START + 00:16:00	Load the +Y SA azimuth and elevation gimbal target angles for the desired post-deployment orientation (same as ANS orientation).
14.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_ANS inboard gimbal angle = SAM_EL_ANS		SALMTA	T = DPLY_START + 00:16:01	Load the -Y SA azimuth and elevation gimbal target angles for the desired deployment orientation.
15.0	IF (S_RWA = OFF) THEN		TEST		If the skew wheel was powered on for this block, is powered back off here. If the skew wheel was already on, it is left on. If one of the orthogonal wheels was turned on by realtime command outside this block because it exhibited undesirable behavior but was worth preserving, it should be turned back off by realtime command outside this block.
15.0.1	turn off skew RWA		ARWASF	T = DPLY_START + 00:25:00	Allow 10 minutes from the time ISH was re-enabled, before turning back off the RWA that is not being used for attitude control. This will ensure that the telemetry from that wheel will be processed by the AACS software for health and status as the wheel spins down to 0 rpm.
15.0.2	use wheels XYZ		SRUXYZ	T = DPLY_START + 00:25:01	After turning off the skew RWA, re-command redundancy management to use the XYZ wheels. This will prevent unnecessary switching of the CIU bus in the event one of the three orthogonal wheels were to fail during the pyro firing event. Thus for example, if the Y wheel were to fail and then the skew wheel was turned back off after the sequence, then REDMAN would believe there were two failed wheels and would switch buses.
15.1	END IF		TEST		
16.0	END HGADPLY BLOCK PART 1		STATE		

Event Table (HGADPLY)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
17.0	START HGADPLY BLOCK PART 2		STATE	T=GMBL_START - 00:00:04	This portion of the block will be triggered by ground command upon verification that boom deployment has occurred sufficiently to allow gimbal motion.
18.0	power up HGA gimbal drive electronics		AGHG1N	T=GMBL_START - 00:00:03	GDE remained unpowered throughout mission to this point to avoid possibility of commanding gimbal motion.
18.1	set HGA control state to off		SAHGCX	T=GMBL_START - 00:00:02	Set to safest state to ensure no HGA motion until gimbal drive is enabled in Event 16.3.
18.2	enable REDMAN (HGA)		SCREDN	T=GMBL_START - 00:00:01	Enable HGA gimbal drive electronics fault detection.
18.3	load HGA azimuth gimbal drive target angle outboard gimbal angle = HGA_AZ_INIT inboard gimbal angle = HGA_EL_FNL		SALHTA	T=GMBL_START - 00:00:01	Load the desired ANS gimbal target angles for the azimuth (outboard) gimbal of the HGA. The azimuth gimbal must be moved first to avoid contact with the boom. The elevation (inboard) gimbal is set to the position it is already in to ensure no movement.
18.4	enable HGA manual gimbal drive rate control		SAHRCE	T=GMBL_START	Enable manual gimbal drive rate control for the HGA. Will command outboard gimbal to the target angle loaded in Event 16.2.
18.5	load HGA elevation gimbal drive target angle outboard gimbal angle = HGA_AZ_FNL inboard gimbal angle = HGA_EL_FNL		SALHTA	T=GMBL_START + 00:10:00	Load the desired ANS gimbal target angles for the elevation (inboard) gimbal of the HGA. The azimuth (outboard) gimbal is set to the position it is already in.
19.0	set attitude control state to ANS		SAGANS	T=GMBL_START + 00:20:32	Return to Array Normal Spin.
20.0	END HGADPLY BLOCK PART 2		STATE		End of HGADPLY block execution.

State Table (HGADPLY)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Control State	array normal spin	ISH »» despin/deploy »» ISH	array normal spin
	RWAs[1]	skew wheel off	all wheels on at specified rpm.	skew wheel off
	Actuators	RWAs	thrusters	RWAs
	HGA gimbal drive electronics	off	on	on
Propulsion				
	Thrusters[2]	disabled and disarmed	enabled, armed, fired	disabled and disarmed
	Thruster catalyst bed heaters[2]	off	on	off
	HGA burnwires	disabled, disarmed	enabled, armed, fired	disabled, disarmed
Telecom				
	Exciter	on		on
	TWNC	off	on	on
	Telemetry modulation	on	off	on
	Telemetry rate	2 kbps	off	10 bps
	LGA	not selected	selected	selected
	HGA	stowed	deployed	deployed and earthpointed

1 If the skew wheel is initially on, its configuration is not changed.
2 The actual thrusters which will be used depend on the selection of odd, even, or both strings.

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4.8 MAPFIG - Mapping Configuration Setup Block

4.8.1 Block Description

This block is used to configure the spacecraft for the mapping phase of the mission. MAPFIG will be performed after the HGA boom has been deployed to its mapping position (via the HGADPLY block) and a HGA gimbal pointing calibration has been performed.

This block is intended for use only once, and need not be coded into the sequencing software. It is included here for documentation purposes.

Block execution must be timed to execute entirely while in sunlight and while not earth occulted.

The block first loads a desired target quaternion and commands the attitude control to the ISH state to achieve an initial "set up" attitude from which to initiate nadir pointing control. This is done primarily to provide sun avoidance protection to the uncovered instruments, which is not provided autonomously by the mapping attitude control states (e.g., Primary, CSA Backup [CSA/BU], and MHSA/BU). The ISH attitude is selected to bring Mars into the field of view for at least three of the four MHSA quadrants.

Approximately a minute after initiating the turn to the mapping "set up" attitude, the solar arrays and HGA gimbal drives are commanded to an initial position from which to initiate autonomous sun and Earth tracking, respectively. Realtime communications with Earth are expected to be retained throughout the execution of this block.

After allowing sufficient time for the spacecraft to acquire the desired "set up" attitude, the pre-loaded standard star catalog for the mapping attitude (as opposed to the cruise phase generated standard star catalog used in the ANS attitude) and the mapping ephemeris are activated. The AACS software is commanded to the mapping mission phase, which redefines the momentum unload axes to recognize the need to spin about the Y axis for mapping instead of the X axis for cruise and orbit insertion. Next the local vertical offset flag used to orient the spacecraft during aerobraking is disabled, ensuring that the +Z axis is aligned with nadir during mapping. One second later the spacecraft is commanded to the CSA/BU mode and the spacecraft acquires the desired nadir pointing using the just activated mapping ephemeris. Transition to the Primary (mapping) attitude control state will be via ground command, after monitoring MHSA performance. This block, therefore, leaves the control state in CSA/BU mode.

While still in sunlight (required to avoid unwinds), autonomous sun tracking is enabled for the two solar arrays. Similarly while still in view of Earth (required to initiate tracking knowledge), autonomous Earth tracking is enabled for the HGA. If autonomous Earth tracking were not enabled while in view of Earth, the HGA's motion would be indeterminate.

4.8.2 Constraints

1. The MHSA shall be turned on for at least 24 hours prior to the start of MAPFIG. After the MHSA has been turned on, redundancy management logic and MHSA temperature monitoring logic shall be enabled in the flight software, although neither will be active and responsive to fault detections until Primary (mapping) mode is selected.

2. A current version of the standard star catalog (for the ANS attitude), a sun referenced star catalog (for “sun star init” AACS mode attitude reinitialization) and a planetary ephemeris (for Earth and Sun target vectors) shall be active when this block initiates. Additionally, the data contained in these files shall be generated with respect to the Mars Reference Coordinate Frame.

3. A standard star catalog (for the mapping attitude) and a mapping ephemeris (for use in CSA B/U mode) shall be pre-loaded on the spacecraft, to be activated by the block at the required time. Additionally, the data contained in these files shall be generated with respect to the Mars Reference Coordinate Frame.

4. The block start time shall be set to ensure execution of the entire block while in neither solar eclipse nor Earth occultation. Autonomous sun tracking must be enabled while in sunlight. and autonomous Earth tracking must be enabled while in view of Earth.

5. The HGA shall be deployed into its mapping position (via the HGADPLY block).

6. The HGA gimbal pointing shall be calibrated after the deployment of the HGA boom to its mapping position.

7. The spacecraft Moments of Inertia shall be updated as required due to the deployment of the HGA to its mapping position.

8. The solar arrays’ GDEs shall be powered on and their redundancy management logic enabled.

9. The HGA GDE shall be powered on and its redundancy management logic enabled.

10. The IMU shall be commanded to low rate mode.

11. The appropriate mapping phase PID control gains shall loaded and enabled.

12. The mapping phase backup attitude control modes logic (i.e., CSA/BU and MHSA/BU) shall be enabled.

13. The mapping ephemeris logic shall be enabled.

14. The flag for autonomous transition to ANS from Sun Star Init, when inertial reference is established, shall be disabled.

15. The flag for autonomous transition to Search mode from Sun Star Init, when inertial reference is established, shall be disabled since Search mode has no autonomous payload sun avoidance protection.

16. The SSRMGR block shall be used to record 2 kbps engineering telemetry from the EDF during execution of this block.

17. During execution of this block, communications shall be configured over the HGA with telemetry modulation turned on. To mitigate the effects of possible pointing errors which could prohibit transmission over the HGA as a result of using the MHSA for the first time, contingency commands should be prepared to select low rate telemetry over the LGA.

18. The Mission Phase Relays shall have been set to Mapping via ground command prior to execution of this block.

19. Since the events in this block are a prelude to the initiation of mapping for the first time, a parameter review prior to the execution of this block is required to ensure a smooth transition.

Parameter Table (MAPFIG)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	MAP_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	The start time of the block shall be set to a time which allows complete execution of all block events while in both sunlight and Earth view. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.2	MARS_QUAT	INPUT	REAL(4)	N/A	-1 to 1 -1 to 1 -1 to 1 -1 to 1	N/A	The quaternion representing the desired nadir pointing “set up” attitude to initiate the transition to mapping nadir pointing control. The selected attitude is set to ensure that at least three quadrants of the MHSA are in view of Mars when CSA/BU mode nadir pointing control is enabled.
1.3	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 00:12:00	00:10:30	Time necessary for the spacecraft to slew to the nadir-pointing “set up” attitude, before initiating CSA/BU mode.
1.4	SAP_AZ_INIT	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA azimuth gimbal angle to position the solar arrays for initiation of autonomous sun tracking.
1.5	SAP_EL_INIT	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA elevation gimbal angle to position the solar arrays for initiation of autonomous sun tracking.
1.6	SAM_AZ_INIT	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA azimuth gimbal angle to position the solar arrays for initiation of autonomous sun tracking.
1.7	SAM_EL_INIT	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA elevation gimbal angle to position the solar arrays for initiation of autonomous sun tracking.
1.8	HGA_AZ_INIT	INPUT	REAL	rad	-1.7453 to 4.5379	N/A	Desired HGA azimuth gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking.
1.9	HGA_EL_INIT	INPUT	REAL	rad	-3.1416 to 3.1416	N/A	Desired HGA elevation gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking.
2.0							No PDB parameters for this block.
3.0							No calculated parameters for this block.

Event Table (MAPFIG)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of MAPFIG block execution.
2.0	load ISH control parameters slew rate = 0.0		SALICP	T= MAP_START	Because the mapping control states do not have autonomous payload sun avoidance capability, it is desired to achieve an initial S/C mapping nadir orientation (+Z axis along the nadir) using the ISH attitude control state, from which to transition to mapping control. The ISH attitude control state does incorporate a sun avoidance algorithm to keep the +Z axis no closer than 30° from the sun vector. The desired ISH state control parameters are first loaded, with the slew rate set to zero.
2.1	load ISH control parameters quaternion = MARS_QUAT		SALICP	T= MAP_START + 00:00:01	Load the desired ISH quaternion to align the Z axis towards Mars.
2.3	set attitude control state to inertial slew hold		SAGISH	T= MAP_START + 00:00:02	Set the attitude control state to ISH, to achieve the desired spacecraft initial nadir orientation (+Z axis along nadir) from which to transition to mapping control. This attitude is set to ensure that at least three quadrants of the MHSA are in view of Mars when CSA backup control is enabled.
3.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_INIT inboard gimbal angle = SAP_EL_INIT		SALPTA	T= MAP_START + 00:01:00	Load the +Y SA azimuth and elevation gimbal target angles for the desired initial position from which to resume autonomous tracking.
3.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_INIT inboard gimbal angle = SAM_EL_INIT		SALMTA	T= MAP_START + 00:01:01	Load the -Y SA azimuth and elevation gimbal target angles for the desired initial position from which to resume autonomous tracking.

Event Table (MAPFIG)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.2	enable +Yb and -Yb solar array manual gimbal drive rate control		SAPRCE SAMRCE	T= MAP_START + 00:01:02	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the azimuth and elevation gimbals will move to the target angles loaded in Events 3.0 and 3.1 at the times the target angles are loaded.
4.0	load HGA gimbal drive target angles outboard gimbal angle = HGA_AZ_INIT inboard gimbal angle = HGA_EL_INIT		SALHTA	T= MAP_START + 00:01:03	Load the HGA inboard and outboard gimbal target angles for the desired initial position from which to resume autonomous tracking.
4.1	enable HGA manual gimbal drive rate control		SAHRCE	T= MAP_START + 00:01:04	Enable manual gimbal drive rate control for the HGA. Will command azimuth and elevation gimbals to the target angles loaded in Event 4.0.
5.0	use new standard star catalog		SANSCU	T= MAP_START + SLEW_DUR	Switch to the pre-loaded mapping phase standard star catalog, to allow star processing in the mapping attitude.
5.1	use new spacecraft ephemeris		SANMEU		Switch to the pre-loaded spacecraft ephemeris used in CSA B/U mode to maintain nadir pointing control in the event the MHSA is not locked onto Mars or has failed.
6.0	set AACS mission phase to “mapping”		SASMPH	T= MAP_START + SLEW_DUR + 00:00:01	Command the AACS software to the mapping mission phase.
6.1	disable A-frame offset flag for CSA backup mode pointing set to 0		SAAFOX		The A-frame offset flag, used during aerobraking to track the spacecraft X axis to the nadir, is disabled for mapping. The mapping attitude tracks the spacecraft +Z axis to the nadir.

Event Table (MAPFIG)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.2	set aacs control state to CSA/Backup		SAGCSA	T= MAP_START + SLEW_DUR + 00:00:02	Command to the CSA Backup AACS state. In this state, the AACS flight software uses the mapping ephemeris to track the spacecraft +Z axis to the nadir. Upon acquiring MHSA lock on Mars and after a suitable monitoring period, the AACS state can be commanded to Primary (Mapping) State via ground command. Mars lock should be nearly instantaneous since the spacecraft is slewed to a nadir orientation in Event 2.3.
7.0	enable +Y SA gimbal drive autonomous tracking		SAPACE	T= MAP_START + SLEW_DUR + 00:00:10	Enable autonomous sun tracking for the SAs. Must be in sunlight.
7.1	enable -Y SA gimbal drive autonomous tracking		SAMACE		
8.0	enable autonomous HGA gimbal drive control		SAHACE	T= MAP_START + SLEW_DUR + 00:00:20	Enable autonomous Earth tracking for the HGA. Must be in Earth view.
9.0	END BLOCK		STATE		End execution of MAPFIG block.

Event Table (MAPFIG)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	ANS	ISH	CSA/Backup
	Actuator Select Flag	RWAs		RWAs
	Local Vertical Offset Flag	Enabled	Disabled	Disabled
	Momentum Unload 2x2 Matrix	Spin About X	Spin About Y	Spin About Y
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)		All Gyro (6 gyro channels)
	IMU Rate Mode	Low Rate Mode		Low Rate Mode
	IMU Frozen Gyro Check	Disabled		Disabled
	Star Processing	Enabled		Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)		3 On, 1 Off (normally skew wheel)
	MHSA Power State	On		On
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On / Disabled	On / Manual Rate Mode	On / Autonomous Tracking
	HGA GDE Power State / Control Mode	On / Disabled	On / Manual Rate Mode	On / Autonomous Tracking
	Sun Avoidance	Enabled		Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled
C&DH				
	EDF Mode	Engineering Mode (2000 bps Telemetry Rate)		Engineering Mode (2000 bps Telemetry Rate)
	XSU Mode	EDF Telemetry to MOT for Real-time Downlink and EDF Telemetry to SSR for Recording		EDF Telemetry to MOT for Real-time Downlink and EDF Telemetry to SSR for Recording

Event Table (MAPFIG)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH (continued)	SSR Power State / Mode	1 Recorder On / Record (via SSRMGR if desired)		1 Recorder On / Record (via SSRMGR if desired)
	PDS Power State / Mode	Off / NA		Off / NA
Mechanisms				
	HGA Boom	Deployed to Mapping Position		Deployed to Mapping Position
Payload				
	MAG/ER	Off		Off
	MOC	Off		Off
	MOLA	Off		Off
	TES	Off		Off
	MR	Off		Off
Telecom	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna	LGA		LGA
	Autonomous Eclipse Management	Enabled (Cycles TWTA beam for selected antenna off/on at eclipse entry/exit)		Enabled (Cycles TWTA beam for selected antenna off/on at eclipse entry/exit)
	TWTA 1 Filament	On		On
	TWTA 1 Beam	On (via AEM when not in eclipse)	Off (via AEM when in eclipse)	On (via AEM when not in eclipse)
	TWTA 2 Filament	Off		Off
	TWTA 2 Beam	Off		Off
	MOT 1 Exciter	Same as TWTA 1 beam state	Same as TWTA 1 beam state	Same as TWTA 1 beam state
	MOT 2 Exciter	Off		Off
	MOT Noncoherent Mode	Disabled		Disabled
	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	Disabled		Disabled
	MOT Ranging	Enabled		Enabled

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4.9 MAP_PB - Mapping Playback Block

4.9.1 Block Description

This block is used during the mapping phase of the mission to return the recorded science data to the ground and to perform the radio science atmospheric occultation measurements. The following three paragraphs offer a high level overview of Autonomous Eclipse Management (AEM) and the mapping data return strategy. The remainder of the text describes the details of the block execution. Figure 4.9.1-1 defines the block parameters geometrically.

A key feature of the data return strategy is the utilization of autonomous eclipse entry/exit detection (AEM) to trigger the data return command script. Specifically, the spacecraft power subsystem software task uses a majority vote scheme of various hardware outputs (i.e., solar array current, short circuit current and battery charge current) to detect eclipse entry and exit and initiate a ground defined script. The script generated by the execution of this block is uplinked and stored in an area of the stored sequence command buffer reserved for reusable mission or phase dependent scripts. The MAP_PB block only utilizes the eclipse entry detection to trigger the data return scripts. The eclipse exit script detection is left disabled. The eclipse ingress triggered data return script has a delay time equal to the difference between eclipse entry time and Earth occultation exit time. This time must be managed by the ground and updated periodically due to the variability in the Earth occultation durations over the mapping phase. To effectively use AEM to sequence the data return, a single script is desired that can be triggered each orbit. This can be accomplished due to the highly repetitive nature of the mapping science data return strategy as described in the following two paragraphs.

The main strategy for data return during mapping is to record 24 hours worth of science data (performed by the SSRMGR block) and to play back the recorded telemetry during one 10-hour DSN tracking pass each day. Three PDS record/playback rate pairs (4/21.3, 8/42.6, 16/85.3 ksps) are available in mapping dependent upon link availability. The record/playback rate ratio is 5.333 such that 24 hours of recorded data can be played back in 4.5 hours. Thus a 10 hour pass is required to playback all the data after accounting for Earth occultations (up to 41 minutes per 117 minute orbit). Four recorders are available for recording/playing back telemetry. Each recorder holds 0.75 Gbits or 52 hours of 4 ksps data, 26 hours at 8 ksps and 13 hours at 16 ksps. Two recorders are required to record 24 hours of 16 ksps.

Assuming a 10 hour DSN pass and a nearly 2 hour orbit period, independent of when the DSN beginning of track (BOT) occurs with respect to the spacecraft's position in orbit, there are assured of being four orbits with complete Earth View Periods or EVPs, in which the spacecraft is not occulted from Earth and the DSN is in view of Mars. The fifth orbit may or may not be a complete one, with respect to the DSN being in view of Mars, and is ignored for the purposes of planning the data return strategy. This extra orbit may be used for real-time downlink to get a spacecraft health and status check as well as accommodating the five minute DSN BOT telemetry lockup requirement (see the MAP_RT block description for details). Thus the playback of the recorded data is performed over four EVPs, with a per EVP duration of 67.5 minutes (4.5 hours divided by 4 EVPs). Each orbit as the spacecraft comes out of Earth occultation, the DSN requires a one minute telemetry lockup period. Due to the lack of a rewind capability with the recorders the recording strategy is modified to ensure the loss of no new data during this lockup period. Rather than recording on a single recorder for 24 hours, the strategy is to record four 6 hour segments, with each segment overlapping the previous by at least 5.33 minutes (i.e., 5.33 minutes of record equals 1 minute of playback). This requires the use of at least two recorders to accommodate the recording overlap, with four recorders being the easiest to implement operationally. However, the block assumes a two recorder strategy, in the event of a recorder failure or power constraints that prohibit all four recorders being on. Therefore, the first record segment for the two recorders is on partition 1 while the second record segments for the two recorders are on partition 2. Thus the record strategy is: 1A (partition 1), 1B (partition 1), 1A (partition 2) and 1B (partition 2), where again each segment is 6 hours long and overlaps the previous segment by 6 minutes). Refer to the MGS Mission Sequence Plan (542-407) for an example of the data return strategy outlined above.

The block begins by enabling AEM.The address of the mapping playback data return script to be triggered by the eclipse entry detection is set autonomously. The timing is determined by the ground to be consistent with the DSN coverage allocation and is set 10 minutes prior to the first eclipse entry of the pass.

Because the HGA is parked in position to minimize spacecraft momentum build up during orbits for which there is no DSN coverage, the HGA is next reoriented to an initial position from which to restart autonomous Earth tracking, and the uplink is configured to the HGA at 125 bps. An option exists in the block to skip this step if the HGA is already in autonomous track mode. This might be the case if the MAP_RT block was executed for the orbit prior to the start of this block to provide an orbit of real-time downlink for spacecraft engineering checkout and to accommodate the DSN BOT telemetry lockup opportunity. Upon completion of the data playback, a related option exists to park the HGA in the momentum managed position or to leave auto tracking enabled. Again for the second option, there may be an additional orbit after all the playback has been completed for real-time telemetry downlink.

Upon eclipse entry detection, the MAP_PB data return script is initiated. A delay time is built into the script which is set to the navigation predicted difference between the time of Earth occultation exit and eclipse entry minus a navigational timing uncertainty and minus the time required for the TWTA to be turned on and warmed up (typically 75 seconds) for the radio science experiment. The value of this navigation timing uncertainty should be very small since Navigation does not need to provide absolute event times for eclipse entry and occultation exit, just the difference between the two.

In addition to the data record and playback strategy outlined above, radio science (RS) observations are performed (if enabled) twice each orbit at Earth occultation ingress and egress. The RS observations involve taking atmospheric profiles by observing the HGA beam as it passes through the atmosphere of Mars from the surface to an altitude of 200 km at occultation egress, and as it passes from 200 km to the surface at ingress. It is also desired to observe the signal for 60-100 seconds "above" 200 km (i.e. after egress and before ingress) for calibration data. Due to navigational uncertainties, the radio science event will begin some time before and after these predicted events to guarantee the collection of useful RS data. The data return script will configure the telecommunications subsystem at the required time for the RS experiment, by turning off the telemetry modulation and placing the MOT in the non-coherent mode with the USO as the downlink frequency source. After the completion of the radio science event, the block will reconfigure the MOT for telemetry return and initiate the recorder playback.

The playback is initiated by configuring the XSU to route telemetry from the selected recorder to the MOT for transmission, enabling data from the selected recorder and finally commanding the selected recorder to playback at the selected rate from the beginning of the selected partition. Upon completion of the playback for that EVP, the data disable command is issued to the recorder, effectively putting it in standby. Each orbit, the selected recorder and partition are reset.

Upon completion of the playback portion of the EVP, the C&DH subsystem is configured for realtime downlink for the remainder of the EVP up to the start of the radio science at ingress event. The realtime downlink will be consistent with the current PDS mode selection (i.e., S&E-1 at either 4, 8, or 16 ksps or S&E-2 at 40 or 80 ksps).

The TWTA is then turned off. The block has an option to power off the MOT Exciter during the eclipse. For aphelion, when SA power availability is a constraint, it may be desired to power off the Exciter. When power is more plentiful, unnecessary Exciter power cycling is undesirable. Note that current flight software turns off the Exciter when the TWTA beam is turned off. Until the (approved) change to disconnect ‘Exciter off’ from ‘TWTA beam off’ is incorporated, the Exciter will be powered off regardless of this option.

After the eclipse entry detection and script trigger for the last EVP, AEM is disabled.

An option exists to command the two recorders into Emergency power mode to conserve power without losing the memory contents.

4.9.2 Constraints

1. Start time for block execution is consistent with DSN allocation.

2. The playback rate to be used in MAPCOM shall match the corresponding record rate, as set in the SSRMGR block, associated with it, to ensure a maximum playback time of approximately 4.5 hours to return 24 hours of recorded data (i.e., 4 ksps record / 21.33 ksps playback, 8 / 42.66, and 16 / 85.33)

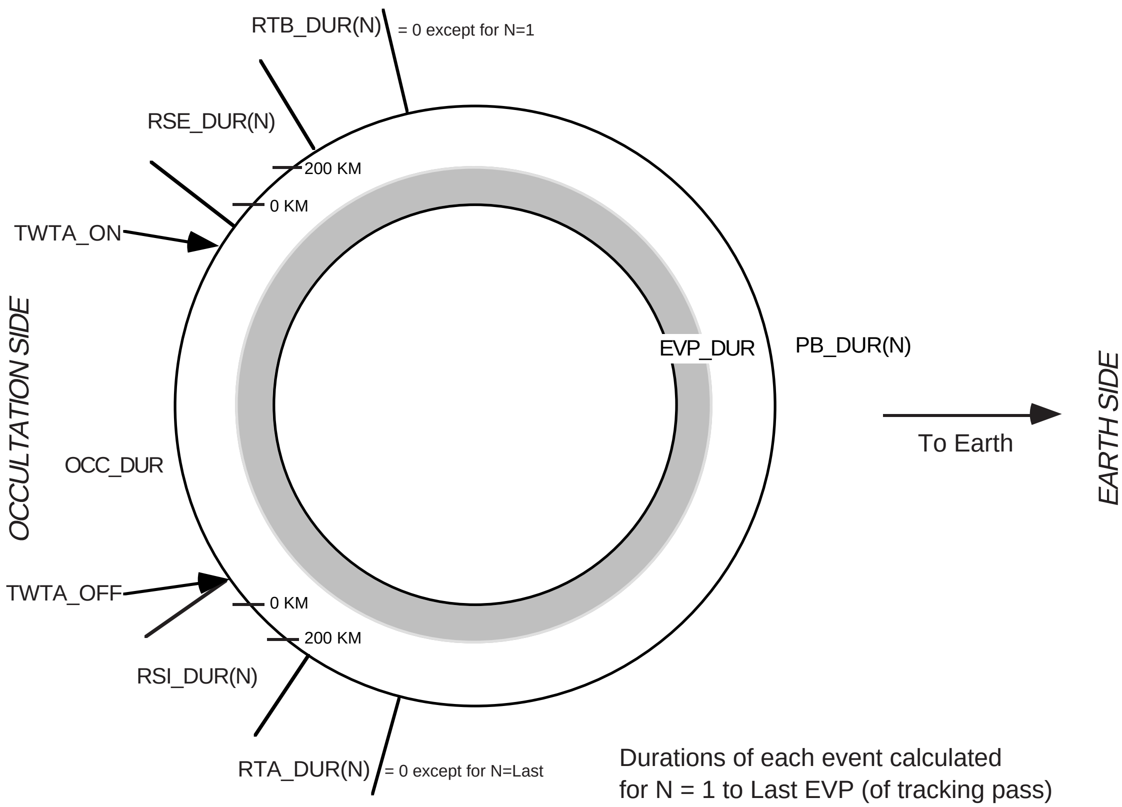
3. Two recorders are powered on and available for playback. Each recorder shall have 12 hours of recorded telemetry on it, 6 hours on partition 1 and 6 hours on partition 2.

4. The PDS is set to the appropriate mode/rate consistent with the available link capability (i.e., 40 or 80 ksps realtime and 4, 8, or 16 ksps record rate associated with the 21.333, 42.667, or 85.333 ksps playback rate, respectively).

5. The modulation index shall be set to 80.0° prior to execution of this block.

6. The recorder playback strategy reflected in this block properly configures the clocks for each recorder. Due to Mars Observer heritage, the clock for recorder 2B requires special consideration. If the playback strategy in this block is modified, it may be necessary to add an additional command prior to the 2B playback to set its clock.

Relationships:
EVP_DUR + OCC_DUR = PERIOD
RDSCI_EGR + MXPB_EVP + RDSCI_ING = EVP_DUR
RTB_DUR(N) + PB_DUR(N) + RTA_DUR(N) = MXPB_EVP
PRE_EGR + RDSCI_EGR = RSE_DUR(N)
RDSCI_ING + POST_ING = RSI_DUR(N)



Durations of each event calculated
for N = 1 to Last EVP (of tracking pass)

RTB_DUR(1) = 10 minutes for DSN initial
lock up and S/C Health Check

RTA_DUR(Last) = DSN time remaining after
SSR playback completed

Figure 4.9.1-1 Geometric Definitions of MAP_PB Parameters

Parameter Table (MAP_PB)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	ECL_START(EVP) EVP = 1 through 4	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Array of eclipse entry times for the four playback orbits of the DSN pass. These times are ground prediction inputs only for expansion and review of the sequence. The actual times are determined by onboard eclipse detection logic.
1.1	NAV_ERROR	INPUT	OFF	hh:mm:ss	0 - 00:05:00	00:00:30	Navigational timing uncertainty applied to the orbital timing predictions used in the block.
1.2	TWTA_ON	INPUT	OFF	hh:mm:ss	00:01:15 - 00:03:00	00:01:15	The amount of time prior to the start of radio science at egress, that the TWTA beam must be turned on. The TWTA beam must be turned on at least 75 seconds prior to the start of radio science, for the output phase variations to stabilize.
1.3	RS_CAL	INPUT	DUR	hh:mm:ss	0 - 00:02:00	00:01:40	The radio science calibration interval above 200 km.
1.4	UNPARK_HGA	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to re-enable HGA GDE autonomous Earth tracking, if the HGA is parked in its minimum momentum position prior to execution of this block.
1.5	HGA_AZ_INIT	INPUT	REAL	rad	-1.7453 to 4.5379	N/A	Desired HGA azimuth gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking. This parameter is only set if Parameter 1.4, UNPARK_HGA is set to TRUE.
1.6	HGA_EL_INIT	INPUT	REAL	rad	-3.1416 to 3.1416	N/A	Desired HGA elevation gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking. This parameter is only set if Parameter 1.4, UNPARK_HGA is set to TRUE.
1.7	PARK_HGA	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to park the HGA in its minimum momentum position upon completion of the data playback pass.
1.8	HGA_AZ_PARK	INPUT	REAL	rad	-1.7453 to 4.5379	N/A	Desired HGA azimuth gimbal angle to park the HGA in a position to minimize spacecraft momentum buildup during non DSN allocation orbits. This parameter is only set if Parameter 1.7, PARK_HGA is set to TRUE.

Parameter Table (MAP_PB)

No	Name	Source	Type	Units	Range	Default	Definition
1.9	HGA_EL_PARK	INPUT	REAL	rad	-3.1416 to 3.1416	N/A	Desired HGA elevation gimbal angle to park the HGA in a position to minimize spacecraft momentum buildup during non DSN allocation orbits. This parameter is only set if Parameter 1.7, PARK_HGA is set to TRUE.
1.10	FIRST_REC	INPUT	CHAR	N/A	REC_1A REC_1B REC_2A REC_2B	REC_1A	First recorder to be played back over the playback orbits of the DSN pass. This recorder is played back over EVP 1 from partition 1 and over EVP 3 from partition 2.
1.11	SECND_REC	INPUT	CHAR	N/A	REC_1A REC_1B REC_2A REC_2B	REC_1B	Second recorder to be played back over the playback orbits of the DSN pass. This recorder is played back over EVP 2 from partition 1 and over EVP 4 from partition 2.
1.12	PB_RATE	INPUT	CHAR	N/A	PB_21 PB_42 PB_85	PB_21	Available recorder playback rates for mapping science data return. The playback rate for the selected recorder will be selected based upon the current record rate being used (as set in the SSRMGR block), to ensure a 5.3333 playback to record ratio, or in other words, to ensure that 24 hours of recorded science telemetry can be returned in 4.5 hours. Thus the 21.333 ksps playback rate is used with the 4 ksps record rate, 42.667 with the 8 ksps record rate and the 85.333 with the 16 ksps. Note the record rate is selected based upon link margin.
1.13	RT_DATA	INPUT	CHAR	N/A	S&E_1A S&E_1B	S&E_1A	Parameter used to select the desired real-time science telemetry downlink rate for any remaining time in the EVP after completion of the playback. Setting RT_DATA to either S&E_1A or 1B will cause the block to downlink the current PDS record/real-time rate, either 4, 8, or 16 ksps. This parameter value must be consistent with the current PDS mode in use.
1.14	EXCITER_OFF	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag set to power off the MOT Exciter during the eclipse. For aphelion, when SA power availability is a constraint, it may be desired to power off the Exciter. When power is more plentiful, unnecessary Exciter power cycling is undesirable. Default is TRUE, turning the Exciter OFF for the duration of the eclipse.

Parameter Table (MAP_PB)

No	Name	Source	Type	Units	Range	Default	Definition
1.15	RADIOSCIENCE	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to configure telecom and solar arrays for radioscience observation for ingress and egress.
1.16	EMER_PWR	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to place the recorders in Emergency mode. This mode preserves the contents of the recorder memory while consuming less power than the Standby mode.
1.17	SAGD_STOP	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to disable autonomous solar array sun tracking during the radio science observations in order to minimize attitude disturbances during the experiment. Use of this option in flight will depend on the magnitude of the measured attitude disturbances to the MOC when autonomous tracking is reenabled and the SA's are rapidly slewed to catch up to the current sun position.
2.0	PERIOD	PDB (OPTG)	DUR	hh:mm:ss	0 - 02:00:00	N/A	The predicted orbit period.
2.1	OCC_DUR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:45:00	N/A	The predicted Earth occultation duration, defined to be the time in which the spacecraft is behind the surface of Mars as seen from Earth.
2.2	ECL_DELAY	PDB (OPTG)	DUR	hh:mm:ss	00:00:00 - 00:50:00	N/A	Predicted time offset between eclipse entry and occultation exit. Used as the script delay time to initiate the EVP data return events when the EVP data return script is triggered by autonomous eclipse entry detection.
2.3	RDSCI_EGR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:06:00	N/A	The predicted duration of the radio science at egress measurement, equal to the s/c predicted time of passage from 0 to 200 km.
2.4	RDSCI_INGR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:06:00	N/A	The predicted duration of the radio science at ingress measurement, equal to the s/c predicted time of passage from 200 to 0 km.

Parameter Table (MAP_PB)

No	Name	Source	Type	Units	Range	Default	Definition
3.0	RSE_DUR	CALC	DUR	hh:mm:ss	0 - 00:10:00	N/A	The duration allocated to the radio science at egress measurement, equal to the s/c predicted time of passage from 0 - 200 km plus a calibration interval above 200 km, plus some time for navigational uncertainty and refraction of the transmission path. RSE_DUR = RDSCI_EGR + RS_CAL + 2*(NAV_ERROR)
3.1	RSI_DUR	CALC	DUR	hh:mm:ss	0 - 00:10:00	N/A	The duration allocated to the radio science at ingress measurement, equal to the s/c predicted time of passage from 200 - 0 km plus a calibration interval above 200 km, plus some time for navigational uncertainty and refraction of the transmission path. RSI_DUR = RDSCI_INGR + RS_CAL + 2*(NAV_ERROR)
3.2	RTA_DUR	CALC	DUR	hh:mm:ss	0 - 01:20:00	N/A	Remaining time in the EVP allocated to realtime transmission after accounting for radio science and playback durations. RTA_DUR = PERIOD - OCC_DUR -RSE_DUR - 01:08:38 - RSI_DUR + 2 * NAV_ERROR

3.3	REC_SEL(EVP)	CALC	CHAR	N/A	REC_1A
					REC_1B
					REC_2A
					REC_2B
						N/A	Array of recorder selections for the four EVPs of the playback pass.
							
							IF (EVP = 1 OR 3) THEN REC_SEL(EVP) = FIRST_REC
							IF (EVP = 2 OR 4) THEN REC_SEL(EVP) = SECND_REC

3.4	PART_SEL(EVP)	CALC	INT	N/A	1 through 8	N/A	Array of recorder partition selections for the four EVPs of the playback pass.
							
							IF (EVP = 1 OR 2) THEN PART_SEL(EVP) = 1
							IF (EVP = 3 OR 4) THEN PART_SEL(EVP) = 2

Parameter Table (MAP_PB)

No	Name	Source	Type	Units	Range	Default	Definition
4.0	AEM_INIT	SEQ	FLAG	N/A	TRUE FALSE	TRUE	Parameter used to specify if this block is being run in “stand alone” or “auto mode”. If the “auto mode” option is selected (set AEM_INI to FALSE), a mapping sequence input block called MAP_PASS is used to automatically generate multiple MAP_PB and MAP_RT block requests,using several input files, including the current DSN allocation file and OPTG file. The MAP_PASS block is used to generate whole mapping sequences autonomously. If it desired to execute this block in “stand alone mode” (i.e., not using the MAP_PASS block), then this parameter is set to TRUE.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of MAP_PB block execution.
2.0	enable AEM ingress script		SWEISE	T= ECL_START(1) - 00:10:00	Enable Autonomous Eclipse Management (AEM) logic in FSW. Triggers ground defined script (as determined below in event 4.0) upon detection of eclipse entry.
3.0	IF (UNPARK_HGA) THEN		TEST		Determine if the HGA requires unparking and autonomous Earth tracking re-enabled for the playback pass.
3.0.1	load HGA gimbal drive target angles outboard gimbal angle = HGA_AZ_INIT inboard gimbal angle = HGA_EL_INIT		SALHTA	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON - 00:10:01	Load the HGA inboard and outboard gimbal target angles for the desired initial position from which to resume autonomous tracking. During non data return orbits in mapping the HGA is parked in a fixed position to minimize the frequency of momentum unloadings.
3.0.2	enable HGA manual gimbal drive rate control		SAHRCE	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON - 00:10:00	Enable manual gimbal drive rate control for the HGA. Will command azimuth and elevation gimbals to the target angles loaded in Events 3.0.1.
3.0.3	enable HGA gimbal drive autonomous tracking		SAHACE	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON	Re-enable autonomous Earth tracking for the HGA, after allowing sufficient time for the HGA to acquire the desired initial position.
3.0.4	switch to HGA uplink		STUHGA		Configure the uplink path to reenable uplink over the HGA after unparking the antenna.
3.0.5	set CDUs to 125 bps uplink rate		TCC1BS TCC2BS		Configure the uplink rate back to 125 bps.
3.1	END IF		TEST		

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0	REPEAT (EVP = 1 TO 4)		LOOP		
4.0.1	*start EVP data return script*		*FSW*	*T = ECL_START(EVP)*	*Execution of EVP data return script (as determined from events 4.0.2 thru 4.0.20 below) is initiated autonomously at eclipse ingress detection.*
4.0.2	turn TWTA beam on		STRPAN	T = ECL_START(EVP) + ECL_DELAY - NAV_ERROR - TWTA_ON	The TWTA beam must be turned on at least 75 seconds prior to the start of radio science, in order for the TWTA output phase variations to stabilize. This command will also turn on the MOT Exciter.
4.0.3	IF (RADIOSCIENCE) THEN		TEST		Determine if a radioscience observation is to be performed.
4.0.3.1	IF (SAGD_STOP = TRUE) THEN		TEST		Determine if autonomous solar array gimbal drive tracking is to be disabled for the radio science experiment.
4.0.3.1.1	disable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACX SAMACX	T = ECL_START(EVP) + ECL_DELAY - NAV_ERROR	Disable autonomous sun tracking for the solar arrays to minimize disturbances to the radioscience observations.
4.0.3.2	END IF		TEST		
4.0.3.3	enable MOT non-coherent mode		TCM12E TCM22E	T = ECL_START(EVP) + ECL_DELAY - NAV_ERROR	Configure the telecommunications subsystem for the egress radio science event. Set the MOT to non-coherent mode, in which the downlink frequency source is generated by the USO, independent of receiver lock status.
4.0.3.4	turn off telemetry modulation to MOT		TCM1MF TCM2MF		It is also desired that the HGA beam to be transmitted through Mar's atmosphere for radio science have no telemetry modulation on it. Thus the telemetry path from the XSU to the MOT is disabled.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.3.5	turn on telemetry modulation to MOT		TCM1MN TCM2MN	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR	Upon completion of the radio science event, the MOT is reconfigured for telemetry return to the ground. Telemetry modulation is turned back on to enable the telemetry path from the XSU to the MOT.
4.0.3.6	disable MOT non-coherent mode		TCM12X TCM22X		The MOT is also be commanded back to the coherent mode, in which the downlink carrier is generated from the uplink carrier when the receiver is phase locked. In this mode, upon loss of receiver phase lock, the MOT will automatically transfer to the USO to generate the downlink carrier.
4.0.3.7	IF (SAGD_STOP = TRUE) THEN		TEST		If disabled for the radio science experiment, re-enable autonomous sun tracking for the solar arrays .
4.0.3.7.1	enable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACE SAMACE		
4.0.3.8	END IF		TEST		
4.0.4	END IF				
4.0.5	set XSU mode for playback from selected recorder source = REC_SEL(EVP)		STMOTC		Configure the XSU to send the telemetry from the selected recorder to the MOT.
4.0.6	begin playback from selected recorder recorder = REC_SEL(EVP) clock = PB_RATE mode = playback partition = PART_SEL(EVP)		STSSRC		Begin playback from the selected recorder at the selected partition.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.7	IF (REC_SEL(EVP) = REC_1A) THEN		TEST		
4.0.7.1	enable data on recorder 1A		CSD1AE	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 00:00:01	Enable recorder 1A to receive telemetry for recording.
4.0.7.2	disable data on recorder 1A		CSD1AX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39	Disable data from recorder 1A to terminate playback for the EVP after 67.5 minutes.
4.0.8	END IF				
4.0.9	IF (REC_SEL(EVP) = REC_1B) THEN		TEST		
4.0.9.1	enable data on recorder 1B		CSD1BE	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 00:00:01	Enable recorder 1B to receive telemetry for recording.
4.0.9.2	disable data on recorder 1B		CSD1BX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39	Disable data from recorder 1B to terminate playback for the EVP after 67.5 minutes.
4.0.10	END IF				

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.11	IF (REC_SEL(EVP) = REC_2A) THEN		TEST		
4.0.11.1	enable data on recorder 2A		CSD2AE	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 00:00:01	Enable recorder 2A to receive telemetry for recording.
4.0.11.2	disable data on recorder 2A		CSD2AX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39	Disable data from recorder 2A to terminate playback for the EVP after 67.5 minutes.
4.0.12	END IF				
4.0.13	IF (REC_SEL(EVP) = REC_2B) THEN		TEST		
4.0.13.1	enable data on recorder 2B		CSD2BE	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 00:00:01	Enable recorder 2B to receive telemetry for recording.
4.0.13.2	disable data on recorder 2B		CSD2BX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39	Disable data from recorder 2B to terminate playback for the EVP after 67.5 minutes.
4.0.14	END IF				
4.0.15	set XSU mode for realtime transmission bits 4-7 set to RT_DATA		STMOTC		Configure the XSU to send the desired realtime telemetry to the MOT.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.16	IF (RADIOSCIENCE) THEN		TEST		Determine if a radioscience observation is to be performed.
4.0.16.1	IF (SAGD_STOP = TRUE) THEN		TEST		Determine if autonomous solar array gimbal drive tracking is to be disabled for the radio science experiment.
4.0.16.1.1	disable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACX SAMACX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR	Disable autonomous sun tracking for the solar arrays to minimize disturbances to the radioscience observations.
4.0.16.2	END IF		TEST		
4.0.16.3	enable MOT non-coherent mode		TCM12E TCM22E	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR	Configure the telecommunications subsystem for the ingress radio science event. Set MOT to non-coherent mode.
4.0.16.4	turn off telemetry modulation to MOT		TCM1MF TCM2MF		Disable the telemetry path from the XSU to the MOT.
4.0.16.5	turn on telemetry modulation to MOT		TCM1MN TCM2MN	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR	Upon completion of the radio science event, the MOT will be reconfigured for telemetry return to the ground. First the telemetry modulation will be turned back on to enable the telemetry path from the XSU to the MOT.
4.0.16.6	disable MOT non-coherent mode		TCM12X TCM22X		The MOT is commanded back to coherent mode.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.16.7	IF (SAGD_STOP = TRUE) THEN		TEST		If disabled for the radio science experiment, re-enable autonomous sun tracking for the solar arrays .
4.0.16.7.1	enable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACE SAMACE	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR	
4.0.16.8	END IF		TEST		
4.0.17	END IF				
4.0.18	turn TWTA beam off		STRPAF	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR + 00:00:01	Turn TWTA beam off to conserve power while in eclipse.
4.0.19	IF (EXCITER_OFF = TRUE) THEN		TEST		
4.0.19.1	turn MOT exciter off		STMOTF		Option to turn off the Exciter for power conservation, at the expense of the potential adverse effects resulting from power cycling the component.
4.0.20	END IF		TEST		
4.0.21	END EVP SCRIPT		STATE		End execution of EVP data return script.
4.1	END LOOP		STATE		
5.0	disable AEM ingress script		SWEISX	T= ECL_START(4) + ECL_DELAY	After final triggering of the EVP data return script, disable AEM script trigger logic prior to next eclipse entry.

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0	IF (PARK_HGA) THEN		TEST		Determine if the HGA is to be parked upon completion of the recorder playback.
6.0.1	load HGA gimbal drive target angles outboard gimbal angle = HGA_AZ_PARK inboard gimbal angle = HGA_EL_PARK		SALHTA	T= ECL_START(4) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR + 00:15:00	Load the HGA inboard and outboard gimbal target angles for the desired parked position used during non data return orbits in mapping to reduce the number of momentum unloadings.
6.0.2	enable HGA manual gimbal drive rate control		SAHRCE	T= ECL_START(4) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR + 00:15:01	Enable manual gimbal drive rate control for the HGA. Will command azimuth and elevation gimbals to the target angles loaded in Events 6.0.1.
6.0.3	switch to LGA uplink		STLGR1	T= ECL_START(4) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR + 00:15:05	Configure the uplink path through the LGA, since uplink through the HGA is precluded while the antenna is parked.
6.0.4	set CDUs to 7.8125 bps uplink rate		TCC1BS TCC2BS		Configure the uplink rate for 7.8125 bps over the LGA.
6.1	END IF		TEST		

Event Table (MAP_PB)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0	IF (EMER_PWR) THEN		TEST		
7.0.1	place first recorder in Emergency power mode bits 0-3 set to FIRST_REC bits 8-11 set to b0110 (emer mode)		STSSRC	T= ECL_START(4) + ECL_DELAY + RSE_DUR - NAV_ERROR + 01:08:39 + RTA_DUR + RSI_DUR + 00:15:06	Place first recorder in Emergency mode for power conservation if desired.
7.0.2	place second recorder in Emergency power mode bits 0-3 set to SECND_REC bits 8-11 set to b0110 (emer mode)		STSSRC		Place second recorder in Emergency mode for power conservation.
7.1	ENDIF		TEST		
8.0	END BLOCK		STATE		End of block execution.

State Table (MAP_PB)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	Primary (Mapping)		Primary (Mapping)
	Actuator Select Flag	RWAs		RWAs
	Local Vertical Offset Flag	Disabled		Disabled
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)		All Gyro (6 gyro channels)
	IMU Rate Mode	Low Rate Mode		Low Rate Mode
	IMU Frozen Gyro Check	Disabled		Disabled
	Star Processing	Enabled		Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)		3 On, 1 Off (normally skew wheel)
	MHSA Power State	On		On
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On / Autonomous Tracking	Autonomous Tracking Disabled for Radio Science	On / Autonomous Tracking
	HGA GDE Power State / Control Mode	On / Disabled (normal) or On / Autonomous Tracking	On / Manual Rate Mode » Autonomous Tracking » Manual Rate Mode	On / Disabled (normal) or On / Autonomous Tracking
	HGA GDE Control Mode	Autonomous Tracking Enabled or Disabled		Disabled
	Sun Avoidance	Enabled	Disabled	Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled
C&DH				
	EDF Mode	Mission Mode (250 bps Telemetry Rate)		Mission Mode (250 bps Telemetry Rate)

State Table (MAP_PB)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH (continued)	XSU Mode	PDS Telemetry to MOT for Real-time Downlink	SSR Telemetry to MOT for Playback » PDS Telemetry to MOT for Real-time Downlink (repeated for desired number of orbits)	PDS Telemetry to MOT for Real-time Downlink
		PDS Telemetry to SSR for Recording		PDS Telemetry to SSR for Recording
	SSR Power State / Mode	3 Recorders On / Data Disabled (subject to power constraints)	Playback at 21.33, 42.66 or 85.33 (per selected PDS mode record rate) » Data Disabled (repeated for desired number of orbits)	3 Recorders On / Data Disabled (subject to power constraints)
		1 Recorder On / Record		1 Recorder On / Record
	PDS Power State / Mode	On / Mode dependent upon telecom link capability		On / Mode dependent upon telecom link capability
Payload				
	MAG/ER	On		On
	MOC	On		On
	MOLA	On		On
	TES	On		On
Telecom				
	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna (Downlink)	HGA		HGA
	Antenna (Uplink)	HGA	LGA 1	HGA
	TWTA 1 Filament	Off		Off
	TWTA 1 Beam	Off		Off
	TWTA 2 Filament	On		On
	TWTA 2 Beam	Off	On	Off
	MOT 1 Exciter	Off		Off
	MOT 2 Exciter	Off (If option selected)	On	Off (If option selected)
	MOT Noncoherent Mode	Disabled	Enabled for Radio Science	Disabled

State Table (MAP_PB)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Telecom (continued)	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	Enabled	Disabled for Radio Science	On
	MOT Ranging	Enabled		On

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4.10 MAP_RT - Mapping Realtime Block

4.10.1 Block Description

This block is used during the mapping phase of the mission to return high rate 40 or 80 ksps S&E-2 real-time telemetry approximately every third day in a 10 hour DSN pass. Additionally this block can be used to supplement the daily playback passes, as described in the MAP_PB block, by providing a real-time EVP prior to and/or upon completion of the SSR data playback. This extra real-time EVP can be used to provide an health check prior to initiation of the playback as well as accommodating the DSN pass telemetry lockup time for the first orbit which can be up to five minutes.

Since this block is very similar to the MAP_PB block (i.e., the only difference is that real-time downlink is performed instead of recorder playback), refer to the text associated with that block for block execution details. The MGS Mission Sequence Plan (542-407) contains an example of a day in mapping, which includes a 10 hour DSN pass for playback (utilizing the MAP_RT block for realtime on the first orbit of the pass and the MAP_PB block to playback the recorded data over the next for orbits) and a 10 hour DSN pass for S&E-2 realtime data return.

Normally, for the DSN pass devoted to realtime downlink every third day, the PDS is configured to one of three S&E-2 modes: RTL, RTM, or RTH.

However, when this block is used to provide an additional realtime orbit in conjunction with a mapping playback pass, there are periods of the mission when the 40 ksps realtime rate cannot be supported unless the DSN switches to one-way mode, sacrificing the uplink. Since the additional realtime orbit during a mapping playback pass is often intended to provide command uplink and verification, the 40 ksps rate becomes unavailable and the PDS should be set to one of the S&E-1 modes (LRC, MRC, or HRC) as dictated by the current telecom link capability.

4.10.2 Constraints

1. Start time for block execution is consistent with DSN allocation.

2. The selected S&E-2 real-time rate (40 or 80 ksps) shall be selected to be consistent with the current telecom link capability.

3. The selected S&E-1 rate of the data stream routed to the recorders, when the PDS is in the S&E-2 realtime mode, shall be selected to be consistent with the current telecom link capability (i.e., the 4, 8 or 16 ksps record rate associated with the 21.333, 42.667, or 85.333 ksps playback rate, respectively).

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	ECL_START(EVP)	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Array of eclipse entry times for the desired number of real-time orbits within the DSN pass. These times are ground prediction inputs only for expansion and review of the sequence. The actual times are determined by onboard eclipse detection logic.
1.1	RT_EVPS	INPUT	INT	N/A	1 through 6	4	Desired number of real-time EVPs for the pass.
1.2	NAV_ERROR	INPUT	OFF	hh:mm:ss	0 - 00:05:00	00:00:30	Navigational timing uncertainty applied to the orbital timing predictions used in the block.
1.3	TWTA_ON	INPUT	OFF	hh:mm:ss	00:01:15 - 00:03:00	00:01:15	The amount of time prior to the start of radio science at egress, that the TWTA beam must be turned on. The TWTA beam must be turned on at least 75 seconds prior to the start of radio science, for the output phase variations to stabilize.
1.4	RS_CAL	INPUT	DUR	hh:mm:ss	0 - 00:02:00	00:01:40	The radio science calibration interval above 200 km.
1.5	UNPARK_HGA	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to re-enable HGA GDE autonomous Earth tracking, if the HGA is parked in its minimum momentum position prior to execution of this block.
1.6	HGA_AZ_INIT	INPUT	REAL	rad	-1.7453 to 4.5379	N/A	Desired HGA azimuth gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking. This parameter is only set if Parameter 1.5, UNPARK_HGA is set to TRUE.
1.7	HGA_EL_INIT	INPUT	REAL	rad	-3.1416 to 3.1416	N/A	Desired HGA elevation gimbal angle to set up an initial HGA position from which to re-enable autonomous Earth tracking. This parameter is only set if Parameter 1.5, UNPARK_HGA is set to TRUE.
1.8	PARK_HGA	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to park the HGA in its minimum momentum position upon completion of the data playback pass.

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
1.9	HGA_AZ_PARK	INPUT	REAL	rad	-1.7453 to 4.5379	N/A	Desired HGA azimuth gimbal angle to park the HGA in a position to minimize spacecraft momentum buildup during non DSN allocation orbits. This parameter is only set if Parameter 1.8, PARK_HGA is set to TRUE.
1.10	HGA_EL_PARK	INPUT	REAL	rad	-3.1416 to 3.1416	N/A	Desired HGA elevation gimbal angle to park the HGA in a position to minimize spacecraft momentum buildup during non DSN allocation orbits. This parameter is only set if Parameter 1.8, PARK_HGA is set to TRUE.
1.11	EXCITER_OFF	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag set to power off the MOT Exciter during the eclipse. For aphelion, when SA power availability is a constraint, it may be desired to power off the Exciter. When power is more plentiful, unnecessary Exciter power cycling is undesirable. Default is TRUE, turning the Exciter OFF for the duration of the eclipse.
1.12	RADIOSCIENCE	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to configure telecom and solar arrays for radioscience observation for ingress and egress.
1.13	PDS_DAY_MODE	INPUT	CHAR	N/A	LRC MRC HRC RTL RTM RTH TEST	RTL	Parameter used to select the desired PDS mode during the realtime DSN pass. The available PDS modes are: LRC is S&E-1 (4 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block. MRC is S&E-1 (8 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block.

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
1.13	PDS_DAY_MODE (concluded)						HRC is S&E-1 (16 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block. RTL is S&E-1 (4 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it will be recorded using the SSRMGR block. The RTL, RTM, or RTH selection must be consistent with the SSRMGR block PDS_MODE selection. The S&E-2 data stream is downlinked. RTM is S&E-1 (8 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it will be recorded using the SSRMGR block. The RTL, RTM, or RTH selection must be consistent with the SSRMGR block PDS_MODE selection. The S&E-2 data stream is downlinked. RTH is S&E-1 (16 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it will be recorded using the SSRMGR block. The RTL, RTM, or RTH selection must be consistent with the SSRMGR block PDS_MODE selection. The S&E-2 data stream is downlinked. TEST is S&E-1 (16 ksps) telemetry and S&E-2 (80 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it will be recorded using the SSRMGR block. The TEST selection must be consistent with the SSRMGR block PDS_MODE selection. The S&E-2 data stream is downlinked.

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
1.14	PDS_NITE_MODE	INPUT	CHAR	N/A	LRC MRC HRC	LRC	Parameter used to select the desired S&E-1 PDS mode after the realtime DSN pass. The available PDS modes are: LRC is S&E-1 (4 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block. MRC is S&E-1 (8 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block. HRC is S&E-1 (16 ksps) telemetry to the XSU for realtime transmission. The data will also be recorded using the SSRMGR block.
1.15	PDS_SOURCE	INPUT	CHAR	N/A	S&E_1A S&E_1B S&E_2A S&E_2B	S&E_2A	Parameter used to select desired PDS data stream for realtime downlink.
1.16	SAGD_STOP	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to disable autonomous solar array sun tracking during the radio science observations in order to minimize attitude disturbances during the experiment. Use of this option in flight will depend on the magnitude of the measured attitude disturbances to the MOC when autonomous tracking is reenabled and the SA's are rapidly slewed to catch up to the current sun position.
2.0	PERIOD	PDB (OPTG)	DUR	hh:mm:ss	0 - 02:00:00	N/A	The predicted orbit period.
2.1	OCC_DUR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:45:00	N/A	The predicted Earth occultation duration, defined to be the time in which the spacecraft is behind the surface of Mars as seen from Earth.

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
2.2	ECL_DELAY	PDB (OPTG)	OFF	hh:mm:ss	00:00:00 - 00:50:00	N/A	Predicted time offset between eclipse entry and occultation exit. Used as the script delay time to initiate the EVP data return events when the EVP data return script is triggered by autonomous eclipse entry detection.
2.3	RDSCI_EGR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:06:00	N/A	The predicted duration of the radio science at egress measurement, equal to the s/c predicted time of passage from 0 to 200 km.
2.4	RDSCI_INGR	PDB (OPTG)	DUR	hh:mm:ss	0 - 00:06:00	N/A	The predicted duration of the radio science at ingress measurement, equal to the s/c predicted time of passage from 200 to 0 km.
3.0	RSE_DUR	CALC	DUR	hh:mm:ss	0 - 00:12:00	N/A	The duration allocated to the radio science at egress measurement, equal to the s/c predicted time of passage from 0 - 200 km plus a calibration interval above 200 km, plus some time for navigational uncertainty and refraction of the transmission path. RSE_DUR = RDSCI_EGR + RS_CAL + 2*(NAV_ERROR)
3.1	RT_DUR	CALC	DUR	hh:mm:ss	0 - 01:20:00	N/A	Remaining time in the EVP allocated to realtime transmission after accounting for radio science and playback durations. RT_DUR = PERIOD - OCC_DUR -RSE_DUR - RSI_DUR + 2 * NAV_ERROR
3.2	RSI_DUR	CALC	DUR	hh:mm:ss	0 - 00:12:00	N/A	The duration allocated to the radio science at ingress measurement, equal to the s/c predicted time of passage from 200 - 0 km plus a calibration interval above 200 km, plus some time for navigational uncertainty and refraction of the transmission path. RSI_DUR = RDSCI_INGR + RS_CAL + 2*(NAV_ERROR)

Parameter Table (MAP_RT)

No	Name	Source	Type	Units	Range	Default	Definition
4.0	AEM_INIT	SEQ	FLAG	N/A	TRUE FALSE	TRUE	Parameter used to specify if this block is being run in “stand alone” or “auto mode”. If the “auto mode” option is selected (set AEM_INI to FALSE), a mapping sequence input block called MAP_PASS is used to automatically generate multiple MAP_PB and MAP_RT block requests,using several input files, including the current DSN allocation file and OPTG file. The MAP_PASS block is used to generate whole mapping sequences autonomously. If it desired to execute this block in “stand alone mode” (i.e., not using the MAP_PASS block), then this parameter is set to TRUE.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of MAP_RT block execution.
2.0	enable AEM ingress script		SWEISE	T= ECL_START(1) - 00:10:00	Enable Autonomous Eclipse Management (AEM) logic in FSW. Triggers ground defined script (as determined below in event 4.0) upon detection of eclipse entry.
3.0	IF (UNPARK_HGA) THEN		TEST		Determine if the HGA requires unparking and autonomous Earth tracking re-enabled for the playback pass.
3.0.1	load HGA gimbal drive target angles outboard gimbal angle = HGA_AZ_INIT inboard gimbal angle = HGA_EL_INIT		SALHTA	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON - 00:10:01	Load the HGA inboard and outboard gimbal target angles for the desired initial position from which to resume autonomous tracking. During non data return orbits in mapping the HGA is parked in a fixed position to minimize the frequency of momentum unloadings.
3.0.2	enable HGA manual gimbal drive rate control		SAHRCE	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON - 00:10:00	Enable manual gimbal drive rate control for the HGA. Will command azimuth and elevation gimbals to the target angles loaded in Events 3.0.1.
3.0.3	enable HGA gimbal drive autonomous tracking		SAHACE	T= ECL_START(1) + ECL_DELAY - NAV_ERROR - TWTA_ON	Re-enable autonomous Earth tracking for the HGA, after allowing sufficient time for the HGA to acquire the desired initial position.
3.0.4	switch to HGA uplink		STUHGA		Configure the uplink path to reenable uplink over the HGA after unparking the antenna.
3.0.5	set CDUs to 125 bps uplink rate		TCC1BS TCC2BS		Configure the uplink rate back to 125 bps.
3.1	END IF		TEST		

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0	REPEAT (EVP = 1 TO RT_EVPS)		LOOP		
4.0.1	*start EVP data return script*		*FSW*	*T = ECL_START(EVP)*	*Execution of EVP data return script (as determined from events 4.0.2 thru 4.0.10 below) is initiated autonomously at eclipse ingress detection.*
4.0.2	turn TWTA beam on		STRPAN	T = ECL_START(EVP) + ECL_DELAY - NAV_ERROR - TWTA_ON	The TWTA beam must be turned on at least 75 seconds prior to the start of radio science, in order for the TWTA output phase variations to stabilize. This command will also turn on the MOT Exciter.
4.0.3	IF (RADIOSCIENCE) THEN		TEST		Determine if a radioscience observation is to be performed.
4.0.3.1	IF (SAGD_STOP = TRUE) THEN		TEST		Determine if autonomous solar array gimbal drive tracking is to be disabled for the radio science experiment.
4.0.3.1.1	disable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACX SAMACX	T = ECL_START(EVP) + ECL_DELAY - NAV_ERROR	Disable autonomous sun tracking for the solar arrays to minimize disturbances to the radioscience observations.
4.0.3.2	END IF		TEST		
4.0.3.3	enable MOT non-coherent mode		TCM12E TCM22E		Configure the telecommunications subsystem for the egress radio science event. Set the MOT to non-coherent mode, in which the downlink frequency source is generated by the USO, independent of receiver lock status.
4.0.3.4	turn off telemetry modulation to MOT		TCM1MF TCM2MF		It is also desired that the HGA beam to be transmitted through Mars' atmosphere for radio science have no telemetry modulation on it. Thus the telemetry path from the XSU to the MOT is disabled.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.3.5	turn on telemetry modulation to MOT		TCM1MN TCM2MN	T = ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR	Upon completion of the radio science event, the MOT is reconfigured for telemetry return to the ground. Telemetry modulation is turned back on to enable the telemetry path from the XSU to the MOT.
4.0.3.6	disable MOT non-coherent mode		TCM12X TCM22X		The MOT is also be commanded back to the coherent mode, in which the downlink carrier is generated from the uplink carrier when the receiver is phase locked. In this mode, upon loss of receiver phase lock, the MOT will automatically transfer to the USO to generate the downlink carrier.
4.0.3.7	IF (SAGD_STOP = TRUE) THEN		TEST		If disabled for the radio science experiment, re-enable autonomous sun tracking for the solar arrays .
4.0.3.7.1	enable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACE SAMACE		
4.0.3.8	END IF		TEST		
4.0.4	END IF				

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.5	set the PDS to the desired mode bits 12-15 set to PDS_DAY_MODE		SCPDSC	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + 00:00:01	Set the PDS to the desired operating mode for the realtime data. Normally, for the DSN pass devoted to realtime downlink every third day, this will be one of the three S&E-2 modes (RTL, RTM, or RTH) to allocate more data to MOC. However, when this block is used to provide an additional realtime orbit in conjunction with a mapping playback pass, there are periods of the mission when the 40 ksps realtime rate cannot be supported unless the DSN switches to one-way mode, sacrificing the uplink. Since the additional realtime orbit during a mapping playback pass is often intended to provide command uplink and verification, the 40 ksps rate becomes unavailable and the PDS should be set to one of the S&E-1 modes (LRC, MRC, or HRC) as dictated by the current telecom link capability.
4.0.6	set the XSU for PDS realtime data bits 4-7 set to PDS_SOURCE		STMOTC		Set the XSU to the desired PDS data stream for realtime data downlink.
4.0.7	*Real-time Downlink*				*The default configuration of the C&DH subsystem in mapping is to downlink real-time telemetry from the PDS at the rate determined by the PDS mode selection. Thus upon re-enabling telemetry modulation in step 4.0.3.5, real-time downlink is immediately initiated.*
4.0.8	set the PDS to desired S&E-1 mode bits 12-15 set to PDS_NITE_MODE		SCPDSC	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR	Set the PDS back to S&E-1 mode to restore more data to other instruments, primarily TES.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.9	IF (RADIOSCIENCE) THEN		TEST		Determine if a radioscience observation is to be performed.
4.0.9.1	IF (SAGD_STOP = TRUE) THEN		TEST		Determine if autonomous solar array gimbal drive tracking is to be disabled for the radio science experiment.
4.0.9.1.1	disable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACX SAMACX	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR	Disable autonomous sun tracking for the solar arrays to minimize disturbances to the radioscience observations.
4.0.9.2	END IF		TEST		
4.0.9.3	enable MOT non-coherent mode		TCM12E TCM22E		Configure the telecommunications subsystem for the ingress radio science event. Set MOT to non-coherent mode.
4.0.9.4	turn off telemetry modulation to MOT		TCM1MF TCM2MF		Disable the telemetry path from the XSU to the MOT.
4.0.9.5	turn on telemetry modulation to MOT		TCM1MN TCM2MN	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR	Upon completion of the radio science event, the MOT will be reconfigured for telemetry return to the ground. First the telemetry modulation will be turned back on to enable the telemetry path from the XSU to the MOT.
4.0.9.6	disable MOT non-coherent mode		TCM12X TCM22X		The MOT is commanded back to coherent mode.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0.9.7	IF (SAGD_STOP = TRUE) THEN		TEST		If disabled for the radio science experiment, re-enable autonomous sun tracking for the solar arrays.
4.0.3.7.1	enable autonomous gimbal drive control for both +Yb and -Yb SAs		SAPACE SAMACE	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR	
4.0.9.8	END IF		TEST		
4.0.10	END IF				
4.0.11	turn TWTA beam off		STRPAF	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR + 00:00:01	Turn TWTA beam off to conserve power while in eclipse.
4.0.12	IF (EXCITER_OFF = TRUE) THEN		TEST		
4.0.12.1	turn MOT exciter off		STMOTF		Option to turn off the Exciter for power conservation, at the expense of the potential adverse effects resulting from power cycling the component.
4.0.13	END IF		TEST		
4.0.14	END EVP SCRIPT		STATE		End execution of EVP data return script.
4.1	END LOOP		STATE		
5.0	disable AEM ingress script		SWEISX	T= ECL_START(EVP) + ECL_DELAY EVP = RT_EVPS	After final triggering of the EVP data return script, disable AEM script trigger logic prior to next eclipse entry.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0	IF (PARK_HGA) THEN		TEST		Determine if the HGA is to be parked upon completion of the SSR playback.
6.0.1	load HGA gimbal drive target angles outboard gimbal angle = HGA_AZ_PARK inboard gimbal angle = HGA_EL_PARK		SALHTA	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR + 00:15:00 EVP = RT_EVPS	Load the HGA inboard and outboard gimbal target angles for the desired parked position used during non data return orbits in mapping to reduce the number of momentum unloadings.
6.0.2	enable HGA manual gimbal drive rate control		SAHRCE	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR + 00:15:01 EVP = RT_EVPS	Enable manual gimbal drive rate control for the HGA. Will command azimuth and elevation gimbals to the target angles loaded in Events 6.0.1.
6.0.3	switch to LGA uplink		STLGR1	T= ECL_START(EVP) + ECL_DELAY + RSE_DUR - NAV_ERROR + RT_DUR + RSI_DUR + 00:15:05 EVP = RT_EVPS	Configure the uplink path through the LGA, since uplink through the HGA is precluded while the antenna is parked.

Event Table (MAP_RT)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.0.4	set CDUs to 125 bps uplink rate		TCC1BS TCC2BS		Configure the uplink rate for 7.8125 bps over the LGA.
6.1	END IF		TEST		
7.0	END BLOCK		STATE		End of block execution.

State Table (MAP_RT)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	Primary (Mapping)		Primary (Mapping)
	Actuator Select Flag	RWAs		RWAs
	Local Vertical Offset Flag	Disabled		Disabled
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)		All Gyro (6 gyro channels)
	IMU Rate Mode	High Rate Mode		High Rate Mode
	IMU Frozen Gyro Check	Disabled		Disabled
	Star Processing	Enabled		Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)		3 On, 1 Off (normally skew wheel)
	MHSA Power State	On		On
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On / Autonomous Tracking	Autonomous Tracking Disabled for Radio Science	On / Autonomous Tracking
	HGA GDE Power State / Control Mode	On / Disabled (normal) or On / Autonomous Tracking	On / Manual Rate Mode » Autonomous Tracking » Manual Rate Mode	On / Disabled (normal) or On / Autonomous Tracking
	HGA GDE Control Mode	Autonomous Tracking Enabled or Disabled		Disabled
	Sun Avoidance	Enabled	Disabled	Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled
C&DH				
	EDF Mode	Mission Mode (250 bps Telemetry Rate)		Mission Mode (250 bps Telemetry Rate)

State Table (MAP_RT)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH (continued)	XSU Mode	PDS Telemetry to MOT for Real-time Downlink and PDS Telemetry to SSR for Recording		PDS Telemetry to MOT for Real-time Downlink and PDS Telemetry to SSR for Recording
	SSR Power State / Mode	3 Recorders On / Data Disabled (subject to power constraints) 1 Recorder On / Record	Playback at 21.33, 42.66 or 85.33 (per selected PDS mode record rate) » Data Disabled (repeated for desired number of orbits)	3 Recorders On / Data Disabled (subject to power constraints) 1 Recorder On / Record
	PDS Power State / Mode	On / Mode dependent upon telecom link capability		On / Mode dependent upon telecom link capability
Payload				
	MAG/ER	On		On
	MOC	On		On
	MOLA	On		On
	TES	On		On
Telecom				
	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna (Downlink)	HGA		HGA
	Antenna (Uplink)	HGA	LGA 1	HGA
	TWTA 1 Filament	Off		Off
	TWTA 1 Beam	Off		Off
	TWTA 2 Filament	On		On
	TWTA 2 Beam	Off	On	Off
	MOT 1 Exciter	Off		Off
	MOT 2 Exciter	Off(If option selected)	On	Off(If option selected)
	MOT Noncoherent Mode	Disabled	Enabled for Radio Science	Disabled

State Table (MAP_RT)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	Enabled	Disabled for Radio Science	On
	MOT Ranging	Enabled		On

4.11 OTM - Orbit Trim Maneuver Block

4.11.1 Block Description

The OTM block is used to perform orbit trim maneuvers during the mapping and relay phases of the mission. Typical OTMs will be performed as drag makeup burns at periapsis to raise apoapsis to the required altitude.

This block is similar to the ABM block used to perform the thruster maneuvers during the aerobraking phase of the mission. The differences are described below.

Unlike the ABM block there are no commands to manage the SSR recording and playback or to configure the downlink. The OTM event will always be recorded and played back as part of the normal science data collection and return strategy implemented by the SSRMGR and MAP_PB blocks, respectively. Recording and playback specific to the OTM event can also be performed with supplemental calls to the SSRMGR block.

The OTM block also does not manage the downlink. If it is desired to perform the OTM with realtime downlink (assuming there is available power and that the spacecraft is not occulted from the Earth), the OTM can be scheduled to occur during the realtime orbit of a playback or realtime DSN 10 hour pass. The transmitter is then controlled by the MAP_PB or MAP_RT block execution (i.e., beam on/off and autonomous Earth tracking enable/disable). Because autonomous Earth tracking is performed if enabled during the slew to the burn attitude, the ground must analyze the HGA slew path to ensure no soft stop limits are violated.

For normal operations, the OTM will most likely be performed without downlink. In this case, the OTM is simply not scheduled when a playback or realtime DSN pass is scheduled. The HGA will remain in its “parked” or momentum management position throughout the block execution, with autonomous Earth tracking disabled.

Upon completion of the burn, the spacecraft is commanded to the CSA/Backup mode. The spacecraft will slew to desired mapping attitude (i.e. Z_b axis along the nadir). Once the MHSA locks on to Mars, the attitude control state autonomously switches to Primary mode. Autonomous sun tracking for the solar arrays is re-enabled when the spacecraft exits eclipse.

4.11.2 Constraints

1. The MANLOAD block must be executed prior to this block to load the appropriate burn control parameters (i.e., burn direction, delta V, min/max timers, etc.). The maximum burn duration must match the equivalent parameter in the MANLOAD block.

2. The block assumes the Actuator Select Flag is set to reaction wheels. The block maintains wheel speeds at their current values during maneuver execution.

3. In the event of a hydrazine half string latchout due to a leaking thruster, the thruster configuration flag shall be set designating which string is to be used, prior to execution of this block. The thruster side selection in the block should be consistent with the flight software knowledge of which side is enabled (String Utilization Flag).

4. An appropriate maneuver abort Contingency Mode cleanup script must be on-board and enabled prior to execution of this block.

5. Several orbits prior to the one on which the OTM will be performed, the IMU shall be commanded to the high rate mode. Additionally the IMU shall be commanded back to low rate mode upon completion of the maneuver. These commands shall be done in the sequence outside of this block.

Parameter Table (OTM)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	CATBED_DUR	INPUT	DUR	hh:mm:ss	00:20:00 - 00:60:00	00:30:00	Desired warmup time of the thruster catalyst bed heaters, before initiating the burn. Normally set to 30 minutes, if both catbed heater strings are enabled, otherwise set to at least 40 minutes. Near mapping aphelion, if power becomes a constraint, the warmup time may be reduced to 20 minutes, but only if both catbed heater strings are enabled. The thrusters are only qualified for 60 cold starts (cold start being defined as an initial catalyst temperature of < 150°F.
1.2	SLEW_DUR	INPUT	DUR	hh:mm:ss	00:05:00 - 00:20:00	00:10:00	Maximum expected slew duration to reach the desired maneuver attitude. Normally set to 10 min for a worst case 180 deg turn. However, the typical slew for an OTM in mapping will be 90 deg, allowing this time to be shortened if required due to power constraints.
1.3	REA_SELECT	INPUT	CHAR	N/A	BOTH EVEN ODD	BOTH	Selects desired REA thruster configuration to be used for the maneuver. Normally set to BOTH, to utilize both strings. If set to ODD (thrusters 1,3,5,7,9,12) or EVEN (2,4,6,8,10,11), then only the respective half side will be enabled for the drag pass.
1.4	SAP_AZ_BURN	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA azimuth gimbal angle to position the solar arrays for the OTM. The solar arrays are positioned to optimize for power, center of mass and restarting autonomous tracking upon completion of the burn.
1.5	SAP_EL_BURN	INPUT	REAL	rad	-3.6652 to 2.6180	N/A	Desired +Y SA elevation gimbal angle to position the solar arrays for the OTM. The solar arrays are positioned to optimize for power, center of mass and restarting autonomous tracking upon completion of the burn.
1.6	SAM_AZ_BURN	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA azimuth gimbal angle to position the solar arrays for the OTM. The solar arrays are positioned to optimize for power, center of mass and restarting autonomous tracking upon completion of the burn.

Parameter Table (OTM)

No	Name	Source	Type	Units	Range	Default	Definition
1.7	SAM_EL_BURN	INPUT	REAL	rad	-2.6180 to 3.6652	N/A	Desired -Y SA elevation gimbal angle to position the solar arrays for the OTM. The solar arrays are positioned to optimize for power, center of mass and restarting autonomous tracking upon completion of the burn.
1.8	ECL_DELAY	INPUT	DUR	hh:mm:ss	(BACKUP_DUR + 00:00:34) to 01:40:00	N/A	Delay from burn start time until end of eclipse, used to initiate autonomous sun tracking for the solar arrays upon exiting eclipse.
2.0	BURN_START	PDB	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to start firing the thrusters for the OTM. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
2.1	MAX_DUR	PDB	DUR	sec	N/A	N/A	The flight software backup maximum burn duration. This parameter must match the value set in the MANLOAD block to load the required flight software maneuver control parameters.
3.0	BACKUP_DUR	CALC	DUR	hh:mm:ss	N/A	N/A	The time from initiation of the burn for the block to resume control and command the spacecraft back to its nominal configuration. The value of BACKUP_DUR shall be 5 seconds greater than the value of the flight software backup maximum burn time (Parameter 2.1 MAX_DUR), to allow the maneuver task time to complete post-burn activities. BACKUP_DUR = MAX_DUR + 00:00:05
3.1	REA_ODD	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the odd string of 4.4 N engines (1,3,5,7,9,12) are to be enabled and armed for the maneuver calculated from the REA thruster configuration selection, Parameter No. 1.3 REA_SELECT. IF (REA_SELECT = BOTH OR ODD) THEN REA_ODD = TRUE

Parameter Table (OTM)

No	Name	Source	Type	Units	Range	Default	Definition
3.2	REA_EVEN	CALC	FLAG	N/A	TRUE FALSE	N/A	Parameter used to determine whether the B string of 4.4 N engines (2,4,6,8,10,11) are to be enabled and armed for the maneuver, calculated from the REA thruster configuration selection, Parameter No. 1.3 REA_SELECT. IF (REA_SELECT = BOTH OR EVEN) THEN REA_EVEN = TRUE

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of orbit trim maneuver (OTM) block execution.
2.0	IF (REA_ODD) THEN		TEST		Warm up the catbed heaters for the odd string of REA thrusters (1,3,5,7,9,12), normally 30 min prior to the burn.
2.0.1	enable REA & catbed heater no 1		PRC01E	T = BURN_START - CATBED_DUR - 00:00:01	
2.0.2	enable REA & catbed heater no 3		PRC03E		
2.0.3	enable REA & catbed heater no 5		PRC05E		
2.0.4	enable REA & catbed heater no 7		PRC07E		
2.0.5	enable REA & catbed heater no 9		PRC09E		
2.0.6	enable REA & catbed heater no 12		PRC12E		
2.1	END IF		TEST		
2.2	IF (REA_EVEN) THEN		TEST		Warm up the catbed heaters for the even string of REA thrusters (2,4,6,8,10,11) nominally 30 min prior to the burn.
2.2.1	enable REA & catbed heater no 2		PRC02E	T = BURN_START - CATBED_DUR	
2.2.2	enable REA & catbed heater no 4		PRC04E		
2.2.3	enable REA & catbed heater no 6		PRC06E		
2.2.4	enable REA & catbed heater no 8		PRC08E		
2.2.5	enable REA & catbed heater no 10		PRC10E		
2.2.6	enable REA & catbed heater no 11		PRC11E		
2.3	END IF		TEST		

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0	set attitude control state to ISH		SAGISH	T= BURN_START - SLEW_DUR - 00:02:00	Attitude control software will slew to the desired attitude, using the reaction wheels. Worst case slew time for a 180 deg turn is about 10 minutes including wheel ramp up and ramp down. In ISH mode, nominal momentum unloading is disabled, although emergency unloading is available. Additionally, star processing is disabled.
4.0	load +Yb solar array gimbal drive target angles outboard gimbal angle = SAP_AZ_BURN inboard gimbal angle = SAP_EL_BURN		SALPTA	T= BURN_START - SLEW_DUR - 00:01:03	Load the +Y SA azimuth and elevation gimbal target angles for the desire burn orientation.
4.1	load -Yb solar array gimbal drive target angles outboard gimbal angle = SAM_AZ_BURN inboard gimbal angle = SAM_EL_BURN		SALMTA	T= BURN_START - SLEW_DUR - 00:01:02	Load the -Y SA azimuth and elevation gimbal target angles for the desire burn orientation.
4.2	enable +Yb solar array manual gimbal drive rate control		SAPRCE	T= BURN_START - SLEW_DUR - 00:01:00	Enable manual gimbal drive rate control for the +Yb and -Yb mounted solar arrays in case it is not already enabled. Normally, the azimuth and elevation gimbals will move to the target angles loaded in Events 4.0 and 4.1 at the times the target angles are loaded.
4.3	enable -Yb solar array manual gimbal drive rate control		SAMRCE		
5.0	switch IMU to accelerometer output format		SRACCF	T= BURN_START - 00:02:01	The IMU will be switched to the accelerometer output format prior to the start of the maneuver. The IMU must be in this mode in order for the flight software maneuver task to process accelerometer telemetry in order to determine delta V accumulation and the maneuver cutoff time.

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.1	enable frozen gyro check		SAFIME	T= BURN_START - 00:02:01	While the IMU is in the accelerometer output format, in which the 6 gyro co-channel compare ability is not available, the IMU is susceptible to a frozen gyro. Thus the frozen gyro check is enabled, allowing REDMAN to select the backup gyro axis if the gyro output remains identical for a selected number of consecutive cycles.
5.2	perform accelerometer null bias measurement		SMMACB	T= BURN_START - 00:02:00	The accelerometer bias measurement is initiated to measure the accelerometer output for a desired time (nominally 100 sec) during a quiescent period prior to the start of the maneuver, in order to determine the accelerometer biases.
6.0	IF (REA_ODD) THEN		TEST		Re-enable the selected 4.4 N thrusters and turn back on their catbed heaters in the event emergency unloading was initiated prior to going to thruster control, resulting in the catbed heaters being turned off and the thrusters disarmed and disabled.
6.0.1	enable REA & catbed heater no 1		PRC01E	T= BURN_START - 00:00:04	
6.0.2	enable REA & catbed heater no 3		PRC03E		
6.0.3	enable REA & catbed heater no 5		PRC05E		
6.0.4	enable REA & catbed heater no 7		PRC07E		
6.0.5	enable REA & catbed heater no 9		PRC09E		
6.0.6	enable REA & catbed heater no 12		PRC12E		
6.0.7	arm REAs 1,3,5,7,9,12		PRTHOA	T= BURN_START - 00:00:02	
6.1	END IF		TEST		

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
6.2	IF (REA_EVEN) THEN		TEST		
6.2.1	enable REA & catbed heater no 2		PRC02E	T= BURN_START - 00:00:03	
6.2.2	enable REA & catbed heater no 4		PRC04E		
6.2.3	enable REA & catbed heater no 6		PRC06E		
6.2.4	enable REA & catbed heater no 8		PRC08E		
6.2.5	enable REA & catbed heater no 10		PRC10E		
6.2.6	enable REA & catbed heater no 11		PRC11E		
6.2.7	arm REAs 2,4,6,8,10,11		PRTHEA	T= BURN_START - 00:00:02	
6.3	END IF		TEST		
7.0	set maneuver configuration flag for thruster burn		SMTHDV	T= BURN_START - 00:00:01	Set the maneuver configuration flag to thrusters, to enable a RCS thruster burn
8.0	set aacs control state to maneuver		SMEXEC	T=BURN_START	The flight software will be commanded to the maneuver control state, to begin the maneuver.
8.1	set nominal actuator select flag to thruster control		SAASFT		Attitude control is maintained by mass expulsion during maneuvers.
8.2	set contingency actuator select flag to thruster control		SAACMT		
8.3	*fire delta V thrusters*		*FSW*	*Performance*	*The flight s/w will begin firing the selected ΔV thrusters to initiate the burn. During the maneuver, the flight software will control the spacecraft attitude to the commanded inertial attitude with the thrusters. Reaction wheel speed will be controlled to the speed that was being commanded just prior to the start of the maneuver.*

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
8.4	*end maneuver; close thruster valves*		*FSW*	*Performance*	*The maneuver task will autonomously end the maneuver when either the desired delta V has been achieved, the backup maximum burn cutoff time occurs, or one of the maneuver abort criteria is met. The maneuver task will transition to the ISH (non-maneuver) state upon completion of the burn.*
8.5	*switch IMU to all gyro format*		*FSW*	*Performance*	*The maneuver task autonomously switches the IMU back to all gyro format.*
9.0	disable frozen gyro check		SAFIMX	T= BURN_START + BACKUP_DUR	Disable frozen gyro check after IMU set back to “all gyro” format by the flight software upon completion of the burn.
10.0	set nominal actuator select flag to RWA control		SAASFW	T= BURN_START + BACKUP_DUR + 00:00:30	Return attitude control to reaction wheels after the maneuver. Thirty seconds are allocated for settling time.
10.1	set contingency actuator select flag to RWA control		SAACMW		
11.0	disarm REAs 1,3,5,7,9,12		PRTHOD	T= BURN_START + BACKUP_DUR + 00:00:31	Disarm thrusters after switching to reaction wheel control.
11.1	disarm REAs 2,4,6,8,10,11		PRTHED		
11.2	disable REAs & catbed heaters no 1, 3, 5		PRCTAX	T= BURN_START + BACKUP_DUR + 00:00:32	Disable thrusters after switching to reaction wheel control.
11.3	disable REAs & catbed heaters no 2,4,6		PRCTBX		
11.4	disable REAs & catbed heaters no 7,9,12		PRCTCX		
11.5	disable REAs & catbed heaters no 8,10,11		PRCTDX		

Event Table (OTM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
12.0	set attitude control state to CSA/Backup		SAGCSA	T= BURN_START + BACKUP_DUR + 00:00:33	Command back to CSA/Backup mode upon completion of the burn. Spacecraft will utilize the mapping ephemeris to re-acquire the mapping nadir orientation. Once the MHSA has re-acquired Mars, the attitude control will autonomously transition to "primary" mapping control state.
13.0	enable +Y SA gimbal drive autonomous tracking		SAPACE	T= BURN_START + ECL_DELAY	Re-enable autonomous sun tracking for the solar arrays upon exiting eclipse.
13.1	enable -Y SA gimbal drive autonomous tracking		SAMACE		
14.0	END BLOCK		STATE		Completion of OTM block execution.

State Table (OTM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
AACS				
	Attitude Control State	Primary	ISH » ISH/Maneuver » CSA/Backup	Primary
	Actuator Select Flag	RWAs	Thrusters (autonomous function in ISH/MNVR mode)	RWAs
	Local Vertical Offset Flag	Disabled		Disabled
	IMU Power State (including CSA, gyros and accelerometers)	On		On
	IMU Output Format	All Gyro (6 gyro channels)	Accelerometer (3 gyro channels, 3 accelerometer channels)	All Gyro (6 gyro channels)
	IMU Rate Mode	Low Rate Mode		Low Rate Mode
	IMU Frozen Gyro Check	Disabled	Enabled	Disabled
	Star Processing	Enabled	Disabled in ISH (autonomous function)	Enabled
	RWAs Power State / Mode	3 On, 1 Off (normally skew wheel)	RWAs in Tach Hold Mode during Burn (autonomous function)	3 On, 1 Off (normally skew wheel)
	MHSA Power State	Off		Off
	SSA Power State	On		On
	SA GDE Power State / Control Mode	On / Auto Tracking Enabled	On / Manual Rate Mode	On / Auto Tracking Enabled
	HGA GDE Power State / Control Mode	On / Disabled (Normal) Auto Tracking not precluded		On / Disabled (Normal)
	Payload Sun Avoidance	Enabled		Enabled
	Sun Monitor Ephemeris Check	Enabled		Enabled

State Table (OTM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH				
	EDF Mode	Mission Mode (250 bps Telemetry Rate)		Mission Mode (250 bps Telemetry Rate)
	XSU Mode	PDS Telemetry to MOT for Realtime Downlink and PDS Telemetry to SSR for Recording		PDS Telemetry to MOT for Realtime Downlink and PDS Telemetry to SSR for Recording
	SSR Power State / Mode	3 Recorders On / Data Disabled (subject to power constraints) and 1 Recorder On / Record		3 Recorders On / Data Disabled (subject to power constraints) and 1 Recorder On / Record
	PDS Power State / Mode	On / Mode dependent upon telecom link capability		On / Mode dependent upon telecom link capability
Payload				
	MAG/ER	On		On
	MOC	On		On
	MOLA	On		On
	TES	On		On
Propulsion				
	(NO) = Normally Open Pyro Valve (NC) = Normally Close Pyro Valve			
	Helium Pressurant Latch Valve 1 & Redundant Pyro Valve 1 (NC)	Opened Not Fired unless LV 1 fails closed		Opened Not Fired unless LV 1 fails closed
	RCS Thruster Latch Valves 2 & 3	Both Open unless leaky thruster detected		Both Open unless leaky thruster detected
	Main Engine Latch Valves 4 & 5 & Redundant Pyro Valves 13 & 14 (NC)	Closed Not fired unless LV4 or LV5 fail closed		Closed Not fired unless LV4 or LV5 fail closed

State Table (OTM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Propulsion (continued)	Pressurant Isolation Pyro Valves 2 through 6	PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Regulator Isolation Pyro Valves 7 through 9	PV 7 (NO) Not Fired unless Primary Regulator leak detected PV 8 (NC) Not Fired unless Backup Regulator brought on line PV 9 (NC) Not Fired unless Backup Regulator brought on line		PV 2 (NC) Not Fired unless PV 4 fails to open for MOI PV 3 (NO) Not Fired PV 4 (NC) Fired Pre-MOI PV 5 (NO) Fired Post-TCM2 PV 6 (NC) Fired Pre-TCM
	Oxidizer Isolation Pyro Valves 10 through 12	PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required		PV 10 (NO) Not Fired unless Quad Check Valve failure detected PV 11 (NC) Not Fired unless Oxidizer tank repressurization required PV12 (NO) Not Fired unless Oxidizer Tank isolation required
	Main Engine	Disabled and Disarmed		Disabled and Disarmed
	RCS Thrusters * odd string (1,3,5,7,9,12) even string (2,4,6,8,10,11) * Note that each thruster has its own enable relay, while the arm relay arms an entire string	Disabled and Disarmed Disabled and Disarmed	Both Strings Enabled and Armed (unless a string latched out due to leaky thruster)	Disabled and Disarmed Disabled and Disarmed

State Table (OTM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
Thermal				
	Main Engine Injector Heaters	Off		Off
	RCS Thruster Catbed Heaters *			
	odd string (1,3,5,7,9,12)	Off	Both Strings On (unless a string latched out due to leaky thruster)	Off
	even string (2,4,6,8,10,11)	Off		Off
	* Note that each thruster has its own catbed heater, that is turned on when the thruster is enabled			
Telecom				
	Note that the following states assume no H/W failures and that normal downlink path configurations are maintained			
	Antenna	HGA		HGA
	TWTA 1 Filament	Off		Off
	TWTA 1 Beam	Off		Off
	TWTA 2 Filament	On		On
	TWTA 2 Beam	Off (Normal, Beam On not precluded)		Off (Normal, Beam on not precluded)
	MOT 1 Exciter	Off		Off
	MOT 2 Exciter	Off (Normal, On not precluded)		Off (Normal, On not precluded)
	MOT Noncoherent Mode	Off		Off
	MOT Noncoherent Source	USO		USO
	MOT Telemetry Modulation	On		On
	MOT Ranging	On		On

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4.12 COMM - Realtime Communications Block

4.12.1 Block Description

During the cruise and aerobraking phases, until the nominal mapping strategy commences, this block is used for spacecraft realtime communications. Mapping phase communications are controlled by the blocks MAP_PB and MAP_RT. The COMM block is used to configure the Telecom and C&DH subsystems for realtime downlink of engineering telemetry from the EDF, or science and engineering telemetry from the PDS. The data flow configuration is shown in figure 4.12.1-1.

All events in the block are timed relative to the start of downlink.

The first event in the block is to set the EDF to either engineering mode (2000 bps) for spacecraft engineering telemetry, or mission mode (250 bps) for science telemetry from the payload packaged with spacecraft engineering telemetry. In these two modes, data can be recorded and/or transmitted in realtime. Emergency mode (10 bps) is also available if desired for marginal link conditions, but emergency mode data can only be transmitted in realtime. Table 4.12.1-1 summarizes the EDF Modes available.

The next event is to set the PDS to one of nine modes, if desired, to downlink science telemetry:

- three modes to select S&E-1 telemetry at low (4 ksps), medium (8 ksps), or high (16 ksps) rate;
- three modes to select S&E-2 at the 40 ksps rate for realtime transmission. S&E-1 telemetry is incidentally also selected at a low, medium or high record rate, but this block does not perform a recording function, so all three are functionally equivalent. Recording can be performed using the SSRMGR block;
- one mode to select S&E-2 at the 80 ksps rate for realtime transmission. S&E-1 telemetry is incidentally also selected at the high record rate, but this block does not perform a recording function, so there is no significance to this record rate. Recording can be performed using the SSRMGR block;
- a special S&E-1 data stream at 4 ksps for the relay phase;
- a special S&E-1 data stream at 4 ksps for PDS health and status without payload science data.

The next event selects the LGA (LGT1 on the concave side of the HGA) or HGA for downlink, or makes no change to the currently selected antenna to avoid unnecessary switching.

The TWTA beam is then powered on or is left unchanged.

The modulation index is next selected corresponding to the selected telemetry rate. The final event in this block is to configure the XSU for realtime transmission and select one of six data sources:

- EDF side A or B for engineering mode.
- PDS side A or B, each with either the S&E-1 or S&E-2 data stream, for mission mode.

4.12.2 Constraints

1. If not already on prior to executing COMM, telemetry modulation must first be turned on external to this block.

Table 4.12.1-1 EDF Modes

	Emergency Mode (EMER)	**Mission Mode (MIS)**	**Engineering Mode (ENG)**
EDF Transmission Rate (bps)	10	250	2000
Segment Interval (sec)	112	4	0.5
Packet Interval (sec)	112	16	2
ETF Interval (sec)	112	32	4
Major Frame (sec)	7168	256	32
No of Minor Frames per Major Frame	1	32	64
Subcommutation	NO	YES	YES
ETF Destination	XSU	XSU	XSU
SCP TLM from SCP to Ground	YES	YES	YES
SCP Packets to SCP	YES	YES	YES
S/C Bus Packets to PDS	NO	YES	NO

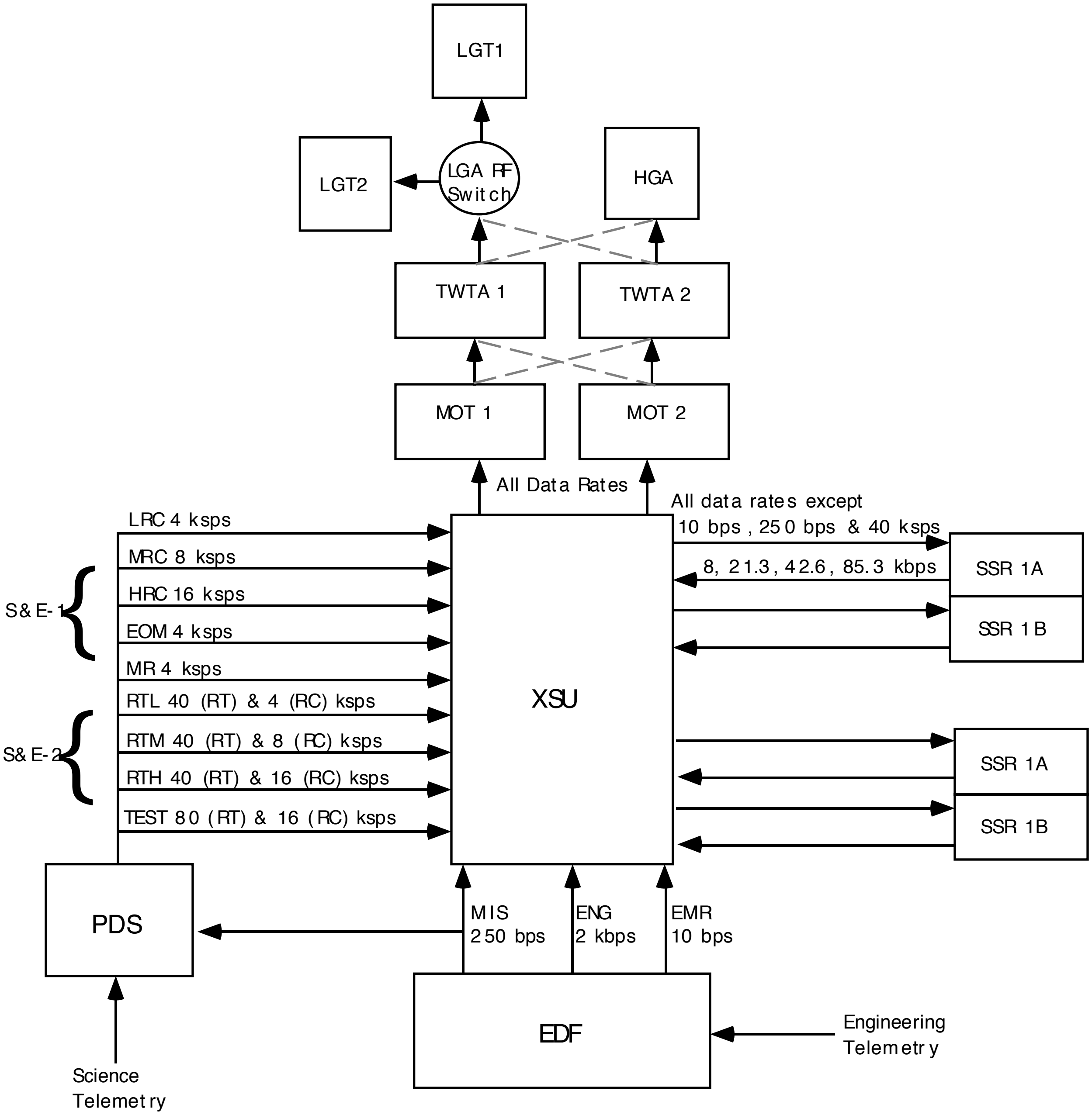

Figure 4.12.1-1 Data Flow Schematic

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.0	COMM_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Time to begin communication activities. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.1	CHANGE_EDF	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to change the EDF mode.
1.2	EDF_MODE	INPUT	CHAR	N/A	ENG MIS EMER	ENG	Parameter used to select the desired EDF mode for realtime transmission (set when CHANGE_EDF = TRUE). If EDF_MODE is set to ‘ENG’ then the EDF will be set to engineering mode. In this mode, the EDF will collect and format s/c telemetry at a 0.5 second frame rate. The EDF will generate Engineering Transfer Frames (ETFs) that are 8000 bits in length and consist of 8 telemetry frames. The EDF will output the ETFs to the XSU at a rate of 2000 bps. The XSU will then output this telemetry to the telecommunication subsystem for transmission to the ground. If EDF_MODE is set to ‘MIS’ then the EDF will be set to mission mode. In this mode, the EDF will collect and format s/c telemetry at a 0.5 second frame rate. The EDF will generate Engineering Transfer Frames (ETFs) which are 8000 bits in length and consist of 8 telemetry frames. The EDF will output the ETFs to the XSU at a rate of 250 bps. The XSU will then output this telemetry to the telecommunications subsystem for transmission to the ground. In mission mode as well, the EDF will also generate PDS packets, one every 4 seconds, and transfer them to the PDS. Each PDS packet consists of 128 8-bit bytes of data. This data will be packaged with the science telemetry from the payload and output from the PDS to the XSU, at the desired data rate (as set by the PDS mode). The XSU will then output this telemetry to the telecommunication subsystem for transmission to the ground.

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.2	EDF_MODE (continued)						If EDF_MODE is set to 'EMER' then the EDF will be set to emergency mode. In this mode, the EDF will output the ETFs to the XSU at a rate of 10 bps for realtime transmission only to the ground.
1.3	CHANGE_PDS	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to change the PDS mode. Note that the EDF must be in mission mode (EDF_MODE = 'MIS') to generate the science and engineering telemetry.
1.4	PDS_MODE	INPUT	CHAR	N/A	LRC MRC HRC RTL RTM RTH TEST MBR EOM	LRC	Parameter used to select the desired PDS mode for realtime transmission of science and engineering telemetry (set when CHANGE_PDS = TRUE). The available PDS modes are: LRC is S&E-1 (4 ksps) telemetry to the XSU for realtime transmission. The data can also be recorded using the SSRMGR block. MRC is S&E-1 (8 ksps) telemetry to the XSU for realtime transmission. The data can also be recorded using the SSRMGR block. HRC is S&E-1 (16 ksps) telemetry to the XSU for realtime transmission. The data can also be recorded using the SSRMGR block. RTL is S&E-1 (4 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it can be recorded using the SSRMGR block. RTL, RTM, and RTH are therefore functionally equivalent in this block. The S&E-2 data stream is downlinked.

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.4	PDS_MODE (concluded)						RTM is S&E-1 (8 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it can be recorded using the SSRMGR block. RTL, RTM, and RTH are therefore functionally equivalent in this block. The S&E-2 data stream is downlinked. RTH is S&E-1 (16 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it can be recorded using the SSRMGR block RTL, RTM, and RTH are therefore functionally equivalent in this block. The S&E-2 data stream is downlinked. TEST is S&E-1 (16 ksps) telemetry and S&E-2 (80 ksps) telemetry to the XSU. The S&E-1 data stream rate is for recording purposes and is not used by this block; it can be recorded using the SSRMGR block. The S&E-2 data stream is downlinked. This mode was originally designed for test purposes, but is available for flight use. MBR is a special S&E-1 (4 ksps) data stream for the relay phase of the mission. EOM is an S&E-1 (4 ksps) engineering only data stream, in which PDS health and status telemetry is output to the XSU for recording. In this mode, there is no payload science data collected.
1.5	TWTA	INPUT	CHAR	N/A	ON NO_CHG	NO_CHG	Parameter used to select TWTA beam condition.

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.6	RT_SOURCE	INPUT	CHAR	N/A	EDF_1 EDF_2 S&E_1A S&E_1B S&E_2A S&E_2B	EDF_1	Parameter used to select the desired data source (i.e., from the EDF or the PDS) for realtime transmission. EDF_1 is engineering data from EDF side 1. The desired rate is set by selecting the appropriate EDF mode (Parameter No. 1.2, EDF_MODE). EDF_2 is engineering data from EDF side 2. The desired rate is set by selecting the appropriate EDF mode (Parameter No. 1.2, EDF_MODE). S&E_1A is science and engineering data stream 1 from PDS side A. The desired rate is set by selecting the appropriate PDS mode (see Parameter No. 1.4, PDS_MODE). S&E_1B is science and engineering data stream 1 from PDS side B. The desired rate is set by selecting the appropriate PDS mode (see Parameter No. 1.4, PDS_MODE). S&E_2A is science and engineering data stream 2 from PDS side A. The desired rate is set by selecting the appropriate PDS mode (see Parameter No. 1.4, PDS_MODE). S&E_2B is science and engineering data stream 2 from PDS side B. The desired rate is set by selecting the appropriate PDS mode (see Parameter No. 1.4, PDS_MODE).

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.7	MOD_INDEX	INPUT	CHAR	N/A	42.3_DEG 44.8_DEG 47.3_DEG 49.9_DEG 52.4_DEG 54.9_DEG 57.4_DEG 59.9_DEG 62.6_DEG 65.0_DEG 67.4_DEG 69.9_DEG 72.4_DEG 75.0_DEG 77.5_DEG 80.0_DEG	72.4_DEG	Parameter used to select the required modulation index for the desired downlink data rate. The first table is the list of modulation indices available only for the 10 bps and 250 bps telemetry rates. The second table is the list of modulation indices available for all telemetry rates above 250 bps. The tables list the available modulation indices, the modulation voltage supplied to the MOT and the telemetry rates intended for use with the selected modulation index. MOD_INDEX / Amplitude (mV peak) / Intended Use 42.3_DEG / 369 / 10 bps or 250 bps 44.8_DEG / 391 / 10 bps or 250 bps 47.3_DEG / 413 / 10 bps or 250 bps 49.9_DEG / 435 / 10 bps or 250 bps 52.4_DEG / 457 / 10 bps or 250 bps 54.9_DEG / 479 / 10 bps or 250 bps 57.4_DEG / 501 / 10 bps or 250 bps 59.9_DEG / 523 / 10 bps or 250 bps MOD_INDEX / Amplitude (mV peak) / Intended Use 62.6_DEG / 546 / over 250 bps 65.0_DEG / 567 / over 250 bps 67.4_DEG / 588 / over 250 bps 69.9_DEG / 610 / over 250 bps 72.4_DEG / 632 / 2 kbps & over 75.0_DEG / 654 / 4 kbps & over 77.5_DEG / 676 / 4 kbps & over 80.0_DEG / 698 / 8 kbps & over Note that the XSU will automatically provide the required subcarrier frequency when the modulation index is set for the desired telemetry rate. For all mod indices listed in the first table above (i.e. all telemetry rates equal to or below 250 bps), the subcarrier frequency selected will be 21.33 kHz. For all mod indices listed in the second table (i.e. all data rates greater than 250 bps), the XSU will set the subcarrier frequency to 320 kHz.

Parameter Table (COMM)

No.	Name	Source	Type	Units	Range	Default	Definition
1.8	XSU_STATUS	INPUT	CHAR	N/A	BOTH_OK XSU1_OK XSU2_OK	BOTH_OK	Parameter used to select the current operational status of XSU sides 1 and 2. If set to BOTH_OK, then XSU side 1 and XSU side 2 are both operational. If set to XSU1_OK, then XSU side 1 is operational and XSU side 2 has failed. If set to XSU2_OK, then XSU side 2 is operational and XSU side 1 has failed.
1.9	ANTENNA	INPUT	CHAR	N/A	LGT1 HGA NO_CHG	NO_CHG	Parameter used to select the transmit antenna, or to remain on the current selection.
2.0							No PDB parameters for this block.
3.0	XSU_1	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 1 as operational, when setting the modulation index for the desired subcarrier and telemetry rates. IF (XSU_STATUS = BOTH_OK OR XSU1_OK) THEN XSU_1 = TRUE ELSE XSU_1 = FALSE
3.1	XSU_2	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 2 as operational, when setting the modulation index for the desired subcarrier and telemetry rates. IF (XSU_STATUS = BOTH_OK OR XSU2_OK) THEN XSU_2 = TRUE ELSE XSU_2 = FALSE

Event Table (COMM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of COMM block execution.
2.0	IF (CHANGE_EDF) THEN		TEST	T = COMM_START - 00:00:50	Determine if the EDF mode is to be changed.
2.0.1	set the EDF to the desired mode mode = EDF_MODE		SCEDFC		Set the EDF to the desired operating mode.
2.1	END IF		TEST		
2.2	IF (CHANGE_PDS) THEN		TEST	T = COMM_START - 00:00:40	Determine if the PDS mode is to be changed.
2.2.1	set the PDS to the desired mode mode = PDS_MODE		SCPDSC		Set the PDS to the desired operating mode.
2.3	END IF		TEST		
3.0	IF (ANTENNA = LGT1) THEN		TEST		
3.0.1	switch to LGA 1 for transmit and receive		STLGT1 STLGR1	T = COMM_START - 00:00:20	
3.1	END IF		TEST		
3.2	IF (ANTENNA = HGA) THEN		TEST		
3.2.1	switch to HGA		STUHGA	T = COMM_START - 00:00:20	
3.3	END IF		TEST		
4.0	IF (TWTA = ON) THEN		TEST		Determine if the TWTA is to be powered on.
4.0.1	turn TWTA beam on		STRPAN	T = COMM_START - 00:00:10	
4.1	END IF		TEST		

Event Table (COMM)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
5.0	set the modulation index for desired realtime data rate mod index = MOD_INDEX	XSU_1 XSU_2	CXSPG1 CXSPG2	T = COMM_START - 00:00:01	Set the required modulation index for the desired data rate.
5.1	set XSU mode for realtime transmission source = RT_SOURCE		STMOTC	T = COMM_START	Configure the XSU to send the desired realtime telemetry to the MOT.
6.0	END BLOCK		STATE		

State Table (COMM)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH				
	EDF mode[1]	undefined	mission mode	mission mode
		undefined	engineering mode	engineering mode
		undefined	emergency mode	emergency mode
	PDS mode[2]	undefined	LRC	LRC
		undefined	MRC	MRC
		undefined	HRC	HRC
		undefined	RTL	RTL
		undefined	RTM	RTM
		undefined	RTH	RTH
		undefined	TEST	TEST
		undefined	MBR	MBR
		undefined	EOM	EOM
	XSU mode[3]	undefined	EDF_1	EDF_1
		undefined	EDF_2	EDF_2
		undefined	S&E_1A	S&E_1A
		undefined	S&E_1B	S&E_1B
		undefined	S&E_2A	S&E_2A
		undefined	S&E_2B	S&E_2B
Telecom				
	modulation index[4]	undefined	one of 16 values	one of 16 values
	antenna[5]	undefined	HGA or LGT1	HGA or LGT1
	TWTA beam[6]	undefined	on or off	on or off

1 The final state of the EDF depends upon which of the three mode options is exercised.
2 The final state of the PDS depends upon which of the nine mode options is exercised.
3 The final state of the XSU depends upon which of the six mode options is exercised.
4 The final state of the modulation index depends upon which of the sixteen options is exercised.
5 The final state of the antenna selection depends upon which of the two options is exercised.
6 The final state of the TWTA beam depends upon which of the two options is exercised.

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4.13 SSRMGR - Solid State Recorder Management Block

4.13.1 Block Description

SSRMGR is used during all phases of the mission to record engineering or science & engineering data onto the Solid State Recorders (SSR). Two recorders comprise one SSR. During the cruise and aerobraking phases, this block is also used to perform recorder playback functions. Mapping phase playbacks are controlled by the block MAP_PB. The SSRMGR block is used to configure the Telecom and C&DH subsystems for recording or playback of engineering telemetry from the EDF, or science and engineering telemetry from the PDS.

Note that the terminology convention for this and all blocks using the SSRs is that there are *two* SSRs and with *two* recorders in each SSR, for a total of *four* recorders.

All events in the block are timed relative to the start of recording or playback.

Recording:

For recording, the first event in the block is to set the EDF to either engineering mode (2000 bps) for spacecraft engineering telemetry, or mission mode (250 bps) for science telemetry from the payload packaged with spacecraft engineering telemetry. The SSRs do not support recording of the 10 bps emergency mode data stream, so that option is not included in this block. An option bypasses any change to the EDF mode if the current mode is satisfactory. See figure 4.12.1-1 and table 4.12.1-1 for a summary of EDF modes and data flow.

The next event is to set the PDS to one of nine modes, if desired, to record science telemetry:

- three modes to select S&E-1 telemetry at low (4 ksps), medium (8 ksps), or high (16 ksps) rate;
- three modes to select S&E-1 telemetry at low (4 ksps), medium (8 ksps), or high (16 ksps) rate, and S&E-2 at the 40 ksps rate for realtime transmission. This block does not perform a realtime downlink function, but the realtime data can be transmitted using the COMM block. The same options as are available in the COMM block are available here for commonality;
- one mode to select S&E-1 telemetry at high (16 ksps) rate and S&E-2 at the 80 ksps rate for realtime transmission. This block does not perform a realtime downlink function, but the realtime data can be transmitted using the COMM block. The same option as is available in the COMM block is available here for commonality;
- a special S&E-1 data stream at 4 ksps for the relay phase;
- a special S&E-1 data stream at 4 ksps for PDS health and status without payload science data.

The recording rate is determined by the selected EDF or PDS mode selection.

The next event clears all partitions on the selected recorder prior to recording, if desired. If all partitions are not cleared, the allowable record duration on the selected partition is defined by the current partition size. Attempting to record beyond the current partition size results in the recorder transferring to standby status.

Next, the selected recorder is commanded to active status and recording begins. If the recorder is in its low power Emergency mode, the record command restores it to normal operations. The recording duration is specified, and the desired partition is selected. One of four data sources is also selected:

- EDF side A or B for engineering mode.
- PDS side A or B for mission mode S&E-1 data.

After the specified recording duration has elapsed, the selected recorder is returned to standby status. An option allows selection of the SSR Emergency mode which preserves the contents of the recorder memory while consuming substantially less power.

Playback:
For playback, the first event in the block is to set the modulation index to one of eight values corresponding to the desired playback rate. Next, the XSU is configured for playback from the selected recorder.

The selected recorder is then commanded to active status and playback begins. If the recorder is in its low power Emergency mode, the playback command restores it to normal operations. The playback duration and rate are specified, and the desired partition is selected. If the selected recorder is 2B, it's clock must be set to 2A's clock before playback commences. This is accomplished with an additional configuration command prior to the normal STSSRC.

After the specified playback duration has elapsed, the selected recorder is returned to standby status. An option allows selection of the SSR Emergency mode which preserves the contents of the recorder memory while consuming less power.

4.13.2 Constraints

1. If not already on prior to executing SSRMGR for playback, telemetry modulation must first be turned on.

2. The desired Telecom configuration must be previously set. This block does not reconfigure antennas or transmitters.

3. Due to a design constraint (created by the decision to duplicate the MO tape recorder interface which had 3 tape transports and 4 electronics packages), simultaneous playback and recording cannot be performed with the two recorders in SSR 2.

4. Any recorder to be used by this block must be powered on for at least 10 minutes prior to execution of this block and have an enable scrub command sent to reset the command bits from the default power on state of record on partition 1. This will ensure that if the block is used to record on partition 1 of the selected recorder (the most probable use following power on) the command will be executed.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	SSR_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Time to begin desired SSR record or playback activity. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.1	SSR_FUNC	INPUT	CHAR	N/A	REC PB	REC	Parameter used to select the desired recorder mode of operation, where REC = record and PB = playback.
1.2	CHANGE_EDF	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to change the EDF operational mode (set when SSR_FUNC = REC).
1.3	EDF_MODE	INPUT	CHAR	N/A	MIS ENG	ENG	Parameter used to designate what mode the EDF is in, either the current mode if CHANGE_EDF is set to FALSE or the new mode if CHANGE_EDF is set to TRUE (set when SSR_FUNC = ‘REC’). If EDF_MODE is set to ENG then the EDF will be set to or is in engineering mode. In this mode, the EDF will collect and format s/c telemetry at a 0.5 second frame rate. The Engineering Transfer Frames (ETFs) will be 8000 bits in length and consist of 8 telemetry frames. The EDF will output the ETFs to the XSU at a rate of 2000 bps, which can then be recorded onto the desired recorder. If EDF_MODE is set to MIS then the EDF will be set to or is in mission mode. In this mode, the EDF will generate PDS packets, one every 4 seconds, and transfer them to the PDS. Each packet consists of 128 8-bit bytes of data. This data will be packaged with the payload telemetry and output from the PDS to the XSU, at the desired rate (as set by the PDS mode), to be recorded onto the desired recorder.
1.4	CHANGE_PDS	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to change the PDS operational mode (set when SSR_FUNC = REC). Note that the EDF must be in mission mode (EDF_MODE = MIS) to generate science and engineering telemetry.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
1.5	PDS_MODE	INPUT	CHAR	N/A	LRC MRC HRC RTL RTM RTH TEST MBR EOM	LRC	Parameter used to select the desired PDS mode for realtime transmission of science and engineering telemetry (set when CHANGE_PDS = TRUE). The available PDS modes are: LRC is S&E-1 (4 ksps) telemetry to the XSU for recording. The data can also be downlinked using the COMM block. MRC is S&E-1 (8 ksps) telemetry to the XSU for recording. The data can also be downlinked using the COMM block. HRC is S&E-1 (16 ksps) telemetry to the XSU for recording. The data can also be downlinked using the COMM block. RTL is S&E-1 (4 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is recorded. The S&E-2 data stream is for downlink purposes and is not used by this block; it can be downlinked using the COMM block. RTM is S&E-1 (8 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is recorded. The S&E-2 data stream is for downlink purposes and is not used by this block; it can be downlinked using the COMM block. RTH is S&E-1 (16 ksps) telemetry and S&E-2 (40 ksps) telemetry to the XSU. The S&E-1 data stream rate is recorded. The S&E-2 data stream is for downlink purposes and is not used by this block; it can be downlinked using the COMM block. RTH and TEST are therefore functionally equivalent in this block.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
1.5	PDS_MODE (continued)						TEST is S&E-1 (16 ksps) telemetry and S&E-2 (80 ksps) telemetry to the XSU. The S&E-1 data stream rate is recorded. The S&E-2 data stream is for downlink purposes and is not used by this block; it can be downlinked using the COMM block. RTH and TEST are therefore functionally equivalent in this block. MBR is a special S&E-1 (4 ksps) data stream for the relay phase of the mission. EOM is an S&E-1 (4 ksps) engineering only data stream, in which PDS health and status telemetry is output to the XSU for recording. In this mode, there is no payload science data collected.
1.6	CLEAR_PARTS	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used if it is desired to clear all partitions on a recorder prior to recording. If the partitions are not cleared then the allowable record duration on a selected partition is defined by the current partition size. Attempting to record beyond the current partition size will result in the recorder transferring to standby mode.
1.7	REC_SEL	INPUT	INT	N/A	REC_1A REC_1B REC_2A REC_2B	REC_1A	Parameter used to select the desired recorder for the desired operation.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
1.8	REC_SOURCE	INPUT	CHAR	N/A	EDF_1 EDF_2 S&E_1A S&E_1B	EDF_1	Parameter used to select the desired data source (i.e., from the EDF or the PDS) for recording (set when SSR_FUNC is set to 'REC'). EDF_1 is engineering data from side 1 of the EDF. EDF_2 is engineering data from side 2 of the EDF. S&E_1A is science and engineering data stream 1 from side A of the PDS. S&E_1B is science and engineering data stream 1 from side B of the PDS.
1.9	PART_SEL	INPUT	INT	N/A	1 - 8	1	Parameter used to select the desired memory partition for recording to or playing back from.
1.10	DURATN	INPUT	DUR	hh:mm:ss	0 - 104:00:00	104:00:00	Parameter used to select the desired recording or playback duration. When recording engineering data at 2 kbps, a single recorder can hold up to 104 hours of data. When recording at the lowest S&E-1 record rate (4 ksps), a single recorder can hold up to 52 hours of data. When recording at the highest S&E-1 record rate (16 ksps), a single recorder can hold up to 13 hours of data. Playback durations will typically be shorter than record durations, so the Range for this parameter is defined by the maximum record duration for one recorder.
1.11	PB_RATE	INPUT	CHAR	N/A	PB_08 PB_21 PB_42 PB_85	PB_08	Desired playback rate/clock. Typically the 8 kbps playback rate is used for playing back 2 kbps engineering telemetry while the 21.333, 42.667, and 85.333 ksps rates are used for the return of science telemetry.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
1.12	MOD_INDEX	INPUT	CHAR	N/A	62.6_DEG 65.0_DEG 67.4_DEG 69.9_DEG 72.4_DEG 75.0_DEG 77.5_DEG 80.0_DEG	80.0_DEG	Parameter used to select the required modulation index for the desired playback downlink data rate. The following table lists the available modulation indices, the modulation voltage supplied to the MOT and the telemetry rates intended for use with the selected modulation index. MOD_INDEX / Amplitude (mV peak) / Intended Use 62.6_DEG / 546 / over 250 bps 65.0_DEG / 567 / over 250 bps 67.4_DEG / 588 / over 250 bps 69.9_DEG / 610 / over 250 bps 72.4_DEG / 632 / 2 kbps & over 75.0_DEG / 654 / 4 kbps & over 77.5_DEG / 676 / 4 kbps & over 80.0_DEG / 698 / 8 kbps & over
1.13	XSU_STATUS	INPUT	CHAR	N/A	BOTH_OK XSU1_OK XSU2_OK	BOTH_OK	Parameter used to select the current operational status of XSU sides 1 and 2, when setting the modulation index for the desired playback rate. If set to BOTH_OK, then XSU side 1 and XSU side 2 are both operational. If set to XSU1_OK, then XSU side 1 is operational and XSU side 2 has failed. If set to XSU2_OK, then XSU side 2 is operational and XSU side 1 has failed.
1.14	EMER_PWR	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used if it is desired to place the selected recorder in its Emergency mode. This mode preserves the contents of the recorder memory while consuming less power than the Standby mode.
2.0							No PDB parameters for this block.

Parameter Table (SSRMGR)

No	Name	Source	Type	Units	Range	Default	Definition
3.0	XSU_1	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 1 as operational, when setting the modulation index for the desired subcarrier and telemetry rates. IF (XSU_STATUS = BOTH_OK OR XSU1_OK) THEN XSU_1 = TRUE ELSE XSU_1 = FALSE
3.1	XSU_2	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag used to designate XSU side 2 as operational, when setting the modulation index for the desired subcarrier and telemetry rates. IF (XSU_STATUS = BOTH_OK OR XSU2_OK) THEN XSU_2 = TRUE ELSE XSU_2 = FALSE

Event Table (SSRMGR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of SSRMGR block execution.
2.0	IF (SSR_FUNC = 'REC') THEN		TEST		Determine if it is desired to configure the C&DH subsystem for SSR recording.
2.0.1	IF (CHANGE_EDF) THEN		TEST		Determine if the EDF mode is to be changed.
2.0.1.1	set the EDF to the desired mode mode = EDF_MODE		SCEDFC	T = SSR_START - 00:01:00	Set the desired EDF operating mode.
2.0.2	END IF		TEST		
2.0.3	IF (CHANGE_PDS) THEN		TEST	T = SSR_START - 00:00:45	Determine if the PDS mode is to be changed.
2.0.3.1	set the PDS to the desired mode mode = PDS_MODE		SCPDSC		Set the desired PDS operating mode.
2.0.4	END IF		TEST		
2.0.5	IF (CLEAR_PARTS) THEN		TEST		Determine if it is desired to clear all recorder memory partitions prior to recording.
2.0.5.1	clear all partitions on selected recorder recorder = REC_SEL mode = clear all partitions)		STSSRC	T = SSR_START - 00:00:02	Clear all partitions on the selected recorder prior to recording.
2.0.6	END IF		TEST		
2.0.7	prepare to record on selected recorder recorder = REC_SEL clock = REC_SOURCE mode = record partition = PART_SEL		STSSRC	T = SSR_START - 00:00:01	Prepare to record on the desired recorder. This command removes the recorder from Emergency power mode if necessary. Recording will begin upon enable command.

Event Table (SSRMGR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.8	IF (REC_SEL = REC_1A) THEN		STATE		
2.0.8.1	recorder 1A enable		CSD1AE	T = SSR_START	Enable recorder 1A to begin recording.
2.0.9	END IF		TEST		
2.0.10	IF (REC_SEL = REC_1B) THEN		STATE		
2.0.10.1	recorder 1B enable		CSD1BE	T = SSR_START	Enable recorder 1B to begin recording.
2.0.11	END IF		TEST		
2.0.12	IF (REC_SEL = REC_2A) THEN		STATE		
2.0.12.1	recorder 2A enable		CSD2AE	T = SSR_START	Enable recorder 2A to begin recording.
2.0.13	END IF		TEST		
2.0.14	IF (REC_SEL = REC_2B) THEN		STATE		
2.0.14.1	recorder 2B enable		CSD2BE	T = SSR_START	Enable recorder 2B to begin recording.
2.0.15	END IF		TEST		
2.0.16	IF (REC_SEL = REC_1A) THEN		STATE		
2.0.16.1	recorder 1A disable		CSD1AX	T = SSR_START + DURATN	At the completion of the record operation, set recorder 1A to standby mode.
2.0.17	END IF		TEST		
2.0.18	IF (REC_SEL = REC_1B) THEN		STATE		
2.0.18.1	recorder 1B disable		CSD1BX	T = SSR_START + DURATN	At the completion of the record operation, set recorder 1B to standby mode.
2.0.19	END IF		TEST		

Event Table (SSRMGR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.20	IF (REC_SEL = REC_2A) THEN		STATE		
2.0.20.1	recorder 2A disable		CSD2AX	T = SSR_START + DURATN	At the completion of the record operation, set recorder 2A to standby mode.
2.0.21	END IF		TEST		
2.0.22	IF (REC_SEL = REC_2B) THEN		STATE		
2.0.22.1	recorder 2B disable		CSD2BX	T = SSR_START + DURATN	At the completion of the record operation, set recorder 2B to standby mode.
2.0.23	END IF		TEST		
2.1	ENDIF		TEST		
3.0	IF (SSR_FUNC = 'PB') THEN		TEST		Determine if SSR playback is to be performed.
3.0.1	set the modulation index for desired playback data rate mod index = MOD_INDEX	XSU_1 XSU_2	CXSPG1 CXSPG2	T = SSR_START - 00:00:03	Set the required modulation index for the desired playback data rate.
3.0.2	set XSU mode for playback from selected recorder source = REC_SEL		STMOTC	T = SSR_START - 00:00:02	Configure the XSU to send playback data from the selected recorder to the MOT.
3.0.3	IF (REC_SEL = REC_2B) THEN		STATE		
3.0.3.1	configure recorder 2B's clock prior to playback recorder = SSR_2A clock = PB_RATE mode = enable scrub partition = 1		STSSRC		Set the clock for recorder 2B. Recorder 2B uses the recorder 2A clock for playback.
3.0.4	END IF		TEST		

Event Table (SSRMGR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0.5	prepare to playback from selected recorder recorder = REC_SEL clock = PB_RATE mode = playback partition = PART_SEL		STSSRC	T = SSR_START - 00:00:01	Prepare to playback from the selected recorder. This command removes the recorder from Emergency power mode if necessary. Playback will begin upon enable command. In the case of recorder 2B, PB_RATE has no effect in this command.
3.0.6	IF (REC_SEL = REC_1A) THEN		STATE		
3.0.6.1	recorder 1A enable		CSD1AE	T = SSR_START	Enable recorder 1A to begin playback.
3.0.7	END IF		TEST		
3.0.8	IF (REC_SEL = REC_1B) THEN		STATE		
3.0.8.1	recorder 1B enable		CSD1BE	T = SSR_START	Enable recorder 1B to begin playback.
3.0.9	END IF		TEST		
3.0.10	IF (REC_SEL = REC_2A) THEN		STATE		
3.0.10.1	recorder 2A enable		CSD2AE	T = SSR_START	Enable recorder 2A to begin playback.
3.0.11	END IF		TEST		
3.0.12	IF (REC_SEL = REC_2B) THEN		STATE		
3.0.12.1	recorder 2B enable		CSD2BE	T = SSR_START	Enable recorder 2B to begin playback.
3.0.13	END IF		TEST		
3.0.14	IF (REC_SEL = REC_1A) THEN		STATE		
3.0.14.1	recorder 1A disable		CSD1AX	T = SSR_START + DURATN	At the completion of the playback operation, set recorder 1A to standby mode.
3.0.15	END IF		TEST		

Event Table (SSRMGR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0.16	IF (REC_SEL = REC_1B) THEN		STATE		
3.0.16.1	recorder 1B disable		CDS1BX	T = SSR_START + DURATN	At the completion of the playback operation, set recorder 1B to standby mode.
3.0.17	END IF		TEST		
3.0.18	IF (REC_SEL = REC_2A) THEN		STATE		
3.0.18.1	recorder 2A disable		CSD2AX	T = SSR_START + DURATN	At the completion of the playback operation, set recorder 2A to standby mode.
3.0.19	END IF		TEST		
3.0.20	IF (REC_SEL = REC_2B) THEN		STATE		
3.0.20.1	recorder 2B disable		CSD2BX	T = SSR_START + DURATN	At the completion of the playback operation, set recorder 2B to standby mode.
3.0.21	END IF		TEST		
3.1	ENDIF		TEST		
4.0	IF (EMER_PWR) THEN		TEST		
4.0.1	place selected recorder in Emergency power mode recorder = REC_SEL mode = emergency power mode		STSSRC	T = SSR_START + DURATN + 00:00:01	Place recorder in Emergency mode for power conservation if desired.
4.1	ENDIF		TEST		
5.0	END BLOCK		STATE		End of SSRMGR block execution.

State Table (SSRMGR)

Subsystem	Subsystem Mode/Component	Initial State	Transition State	Final State
C&DH				
	EDF mode[1]	undefined	mission mode	mission mode
		undefined	engineering mode	engineering mode
	PDS mode[2]	undefined	LRC	LRC
		undefined	MRC	MRC
		undefined	HRC	HRC
		undefined	RTL	RTL
		undefined	RTM	RTM
		undefined	RTH	RTH
		undefined	TEST	TEST
		undefined	MBR	MBR
		undefined	EOM	EOM
	XSU mode[3]	undefined	EDF_1	EDF_1
		undefined	EDF_2	EDF_2
		undefined	S&E_1A	S&E_1A
		undefined	S&E_1B	S&E_1B
	SSR partitioning[4]	undefined	unchanged or cleared	unchanged or cleared
	SSR partition selection[5]	undefined	one of 8 values	one of 8 values
	SSR power mode[6]	undefined	enabled, disabled	disabled
		undefined	enabled, disabled	emergency
Telecom				
	modulation index[7]	undefined	one of 16 values	one of 16 values

1 The transition and final state of the EDF depends upon which of the two mode options is exercised.
2 The transition and final state of the PDS depends upon which of the nine mode options is exercised.
3 The transition and final state of the XSU depends upon which of the four mode options is exercised.
4 The transition and final state of the SSR partitioning depends upon whether the option to clear partitions is exercised.
5 The transition and final state of the SSR partition selection depends upon which of the eight partitions is selected.
6 The transition and final state of the SSR power mode depends upon which of the two options is exercised.
7 The transition and final state of the modulation index depends upon which of the sixteen options is exercised.

4.14 MANLOAD - Maneuver Parameter Load Block

4.14.1 Block Description

This block is used to load the AACS and maneuver flight software parameters required to perform all maneuvers except those during aerobraking, as executed by the MNVR and OTM blocks. This block must be executed prior to executing the desired maneuver.

The first parameters loaded by the MANLOAD block are those which are maneuver-specific. These parameters are required for every maneuver. The Inertial Slew Hold control parameters are first loaded. The desired burn attitude for the maneuver is input by the target to inertial quaternion.

The next parameters consist of the desired ΔV for the maneuver and the minimum and maximum maneuver times. When the maneuver is executed, the flight software will accumulate ΔV on each accelerometer, by integrating the accelerometer outputs, and terminate the maneuver when the accumulated ΔV on the selected axis reaches the desired ΔV. In addition, the flight software will compare the accumulated maneuver time with the selected minimum and maximum burn times, in the event of an accelerometer failure. If the accumulated maneuver time is less than the minimum time, the flight software will continue the maneuver until the minimum burn time is reached. If the maneuver time equals the maximum burn time, the flight software will terminate the maneuver.

The remaining parameters loaded by this block are control parameters which need not be reloaded for every maneuver. This section can be bypassed if the existing onboard parameters are acceptable. First, the PID gains (i.e., rate, position, integral and forward gains) to be used for the maneuver are loaded. The block next loads the initial integral pulse widths for the desired ΔV device (main engine or thrusters) to be used for the maneuver, in order to initialize the integrator. In every maneuver, just prior to ΔV thruster shut-off, the flight software stores these integral values.

Lastly the block loads the maneuver abort parameters. The first set is the acceleration and acceleration rate thresholds, for detection of a stuck thruster upon initiation of the burn. These thresholds will result in the maneuver being aborted before the gyros can become saturated. The final parameters loaded are the position and rate abort thresholds. If either threshold is exceeded at any point during the burn, the maneuver will be terminated.

4.14.2 Constraints

1. The burn type (MAIN_ENG, THRUSTERS, or MOI) made in MANLOAD must match the selection made in the maneuver block to be executed.

2. The maneuver pitchover rate and vector, if applicable, are set in the MNVR block.

3. The maximum burn duration must match the equivalent parameter in the maneuver block to be executed.

Parameter Table (MANLOAD)

No	Name	Source	Type	Units	Range	Default	Comments
1.1	LOAD_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Time to begin maneuver load. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	KR_GAIN	INPUT	REAL(3)	volts/radian/ sec	0 - 1000	N/A	Roll, pitch, and yaw PID rate gain components for the desired maneuver.
1.3	KP_GAIN	INPUT	REAL(3)	volts/radian	0 - 10	N/A	Roll, pitch, and yaw PID proportional gain components for the desired maneuver.
1.4	KU_GAIN	INPUT	REAL(3)	volts/radian- sec	0 -1.0	N/A	Roll, pitch, and yaw PID integral gain components for the desired maneuver.
1.5	KF_GAIN	INPUT	REAL(3)	sec/volt	0 - 10	N/A	Roll, pitch, and yaw PID forward gain components for the desired maneuver.
1.6	BURN_TYPE	INPUT	CHAR	N/A	MAIN_ENG THRUSTERS MOI	N/A	Parameter used to select the type of maneuver to be performed in order to load the correct initial integral terms for the delta V thrusters to be used for the burn. Thus if set to MAIN_ENG, the main engine will be used to provide the delta V for the burn. If set to THRUSTERS, the thrusters will be used to provide the delta V. If set to MOI, the main engine will be used to provide the delta V for the burn, and flight software will prevent an aborted burn.
1.7	INTGRL	INPUT	REAL(3)	N/A	N/A	N/A	The desired initial integral terms used when either the thrusters or the main engine is used to provide the ΔV. The ground has an option to use the values stored by the flight software just prior to engine shut-off, or of entering a desired set of engine initial integral pulse widths.
1.8	ACC_THRSH	INPUT	REAL	rad/(sec)/ (.1sec)	N/A	N/A	Desired acceleration threshold for detection of a stuck thruster. Note that this detection must also be accompanied by an acceleration rate threshold violation (Parameter No. 1.9) to abort a maneuver.

Parameter Table (MANLOAD)

No	Name	Source	Type	Units	Range	Default	Comments
1.9	ACC_RATE_TH	INPUT	REAL	rad/(sec)	N/A	N/A	Desired acceleration rate threshold for detection of a stuck thruster. Note that this detection must also be accompanied by an acceleration threshold violation (Parameter No. 1.8) to abort a maneuver.
1.10	CONTROL	INPUT	FLAG	N/A	TRUE FALSE	TRUE	Flag used to bypass loading of parameters which may remain constant for several maneuvers (i.e., PID gains, initial integral terms, and maneuver abort thresholds). If set to TRUE, the section which loads these general parameters will be executed. If set to FALSE, the section which loads these general parameters will be bypassed.
1.11	POS_THRSH	INPUT	REAL(3)	rad	-1.0 to 1.0	N/A	The desired position error thresholds for aborting the maneuver.
1.12	RATE_THRSH	INPUT	REAL(3)	rad/sec	-0.5 to 0.5	N/A	The desired rate error thresholds for aborting the maneuver.
2.0	BURN_QUAT	PDB	REAL(4)	N/A	N/A	N/A	Target to inertial quaternion to attain the desired burn attitude.
2.1	DELTA_V	PDB	REAL	m/sec	N/A	N/A	Desired delta V for the maneuver. For main engine burns, delta V calculation must include contribution of ullage burn.
2.2	MIN_DUR	PDB	REAL	sec	N/A	N/A	Minimum burn duration. If the accumulated burn time is less than this time, the flight software will continue the burn.
2.3	MAX_DUR	PDB	REAL	sec	N/A	N/A	Maximum burn duration. If the accumulated burn time equals this time and the desired delta V has not been achieved, the flight software will terminate the burn. This parameter must match the value set in the MNVR or OTM block.
3.0							No calculated parameters for this block.

Event Table (MANLOAD)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start of MANLOAD block execution. The following parameters are specific control values and must be set for each maneuver.
2.0	load ISH control parameters quaternion = BURN_QUAT		SALICP	T=LOAD_START	Load the target to inertial quaternion to attain the desired burn attitude.
2.1	load ISH pitch rate pitch_rate = 0.0		SALISR	T= LOAD_START + 00:00:01	Zero the pitchover rate in case it was left non-zero from a previous burn.
2.2	load required delta V ΔV = DELTA_V		SMDELV	T= LOAD_START + 00:00:02	Load the desired delta V for the maneuver. The flight software will terminate the maneuver when the accumulated delta V along the selected axis equals the desired delta V.
2.3	load minimum maneuver duration MIN_DUR		SMDMIN		Load the minimum burn duration for the maneuver. The flight software will start a timer when the maneuver execute command is issued. Until the accumulated burn duration exceeds the minimum burn time, the flight software will continue the burn.
2.4	load maximum maneuver duration MAX_DUR		SMDMAX		Load the maximum burn duration for the maneuver. The flight software will start a timer when the maneuver execute command is issued. If the accumulated burn time equals the maximum burn duration, the flight software will terminate the burn.
2.5	IF (BURN_TYPE = MAIN_ENG .OR. MOI) THEN		TEST		For maneuvers in which the main engine is used for delta V, load the initial integral terms for the engine.
2.5.1	load initial integral terms main engine integral terms = INTGRL		SMINTT	T= LOAD_START + 00:00:03	
2.6	END IF		TEST		

Event Table (MANLOAD)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.7	IF (BURN_TYPE = THRUSTERS) THEN		TEST		For maneuvers in which the thrusters are used for ΔV, load the thruster initial integral terms.
2.7.1	load initial integral terms thruster integral terms = INTGRL		SMINTT	T = LOAD_START + 00:00:03	
2.8	END IF		TEST		
3.0	IF (CONTROL) THEN		TEST		The following parameters are general control values and need not be updated for each maneuver.
3.0.1	load PID rate gains KR_GAIN		SMPDRG	T = LOAD_START + 00:00:04	Load the PID rate gains for the desired maneuver.
3.0.2	load PID proportional gains KP_GAIN		SMPDPG	T = LOAD_START + 00:00:05	Load the PID proportional gains for the desired maneuver.
3.0.3	load PID integral gains KU_GAIN		SMPDIG	T = LOAD_START + 00:00:06	Load the PID integral gains for the desired maneuver.
3.0.4	load PID forward gains KF_GAIN		SMPDFG	T = LOAD_START + 00:00:07	Load the PID forward gains for the desired maneuver.
3.0.5	load excessive acceleration detection threshold ACC_THRSH ACC_RATE_TH		SMABRA	T = LOAD_START + 00:00:08	Load the angular acceleration threshold and acceleration rate threshold for detection of a stuck thruster and subsequent maneuver abort. Violation of both thresholds is required to abort a maneuver.
3.0.6	load maneuver abort thresholds POS_THRSH		SMABRH	T = LOAD_START + 00:00:09	Load the desired maneuver abort position thresholds (axis-by-axis).
3.0.7	load maneuver abort thresholds RATE_THRSH		SMABRH	T = LOAD_START + 00:00:10	Load the desired maneuver abort rate thresholds (axis-by-axis).
3.1	END IF		TEST		
4.0	END BLOCK		STATE		

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4.15 BATT_MAN - Battery Management Block

4.15.1 Block Description

This block is used during cruise and orbit insertion to manage the battery charge path configuration for maneuvers and payload calibration events. The normal configuration during cruise (i.e., when the spacecraft is in ANS) will be to have the batteries disconnected from the Battery Charge Regulator (BCR). If the batteries are left connected to the BCR at the 0.85 A trickle charge rate with a full state of charge, the batteries will critically overheat within several hours. Whenever a propulsive maneuver or payload calibration activity is performed which will place the spacecraft into an attitude such that the batteries will discharge, this block is used to reconnect the batteries to the charge path and after sufficient time to recharge the batteries after returning to ANS, disconnect them again.

4.15.2 Constraints

No constraints

Parameter Table (BATT_MAN)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	BATT_MAN	INPUT	TIME	UTC	N/A	N/A	Desired start time to begin execution of the BATT_MAN block. Normally timed to begin a few minutes before the expected attitude orientation for the maneuver or payload calibration event.
1.1	BATT_DUR	INPUT	DUR	hh:mm:ss	00:00:00 - 04:00:00	01:20:00	Total time batteries are to be left connected to the BCR for the maneuver or payload event. This duration shall be selected based upon expected battery depth of discharge and subsequent recharge time required.
1.2	BCR_SIDE	INPUT	CHAR	N/A	BCR_PRI BCR_BUP	BCR_PRI	Parameter used to determine which BCR is currently in use, either the primary or backup, when reconnecting the batteries to the charge path.
1.3	BATT_STATUS	INPUT	CHAR	N/A	BOTH_OK BAT1_OK BAT2_OK	BOTH_OK	Parameter used to determine the operational status of the batteries when connecting and disconnecting the batteries from the charger.
2.0							No PDB Parameters for this block.

Parameter Table (BATT_MAN)

No	Name	Source	Type	Units	Range	Default	Definition

3.0	PATH_SEL	CALC	CHAR	N/A		N/A	Parameter used to select the correct charge path when reconnecting the batteries to the BCR. Calculated from the battery and BCR status parameters.
							
							IF (BCR_SIDE = BCR_PRI) THEN
							    IF (BATT_STATUS = BOTH_OK) THEN
							        PATH_SEL = BTHPRI
							    ELSE IF (BATT_STATUS = BAT1_OK) THEN
							        PATH_SEL = B1_PRI
							    ELSE IF (BATT_STATUS = BAT2_OK) THEN
							        PATH_SEL = B2_PRI
							ELSE
							    IF (BATT_STATUS = BOTH_OK) THEN
							        PATH_SEL = BTHBUP
							    ELSE IF (BATT_STATUS = BAT1_OK) THEN
							        PATH_SEL = B1_BUP
							    ELSE IF (BATT_STATUS = BAT2_OK) THEN
							        PATH_SEL = B2_BUP
							END IF

4.0	CONTG_MODE	SEQ	FLAG	N/A	TRUE FALSE	FALSE	Parameter used if it desired to set the contingency mode enable flag for the commands in this block. If set to TRUE, then upon entry into contingency mode, these commands would continue executing. If set to FALSE, the remaining commands in the block would not execute upon entry into contingency mode.

Event Table (BATT_MAN)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK ** Note that if the CONTG_MODE parameter is set to TRUE, all commands in the block will be enabled for contingency mode execution.		STATE		Start of battery management block execution.
2.0	turn off 0.18 A charge circuit to both batteries		PWB1TF PWB2TF	T = BATT_START - 00:00:02	Turn off the 0.18A charge circuit to both batteries.
2.1	disable 0.18 A charge circuit to both batteries		PWB1TX PWB2TX	T = BATT_START - 00:00:01	Disable the 0.18A charge circuit to both batteries.
2.2	connect both batteries to BCR dataword 1 = PATH_SEL		SWCHPS	T = BATT_START	Connect both batteries to the current BCR, either primary or secondary.
3.0	disconnect both batteries from BCR address = h2464 dataword = h8440		SISERC	T = BATT_START + BATT_DUR	Disconnect both batteries from the BCR.
3.1	enable 0.18 A charge circuit to both batteries		PWB1TE PWB2TE	T = BATT_START + BATT_DUR + 00:00:01	Enable the 0.18A charge circuit to both batteries.
3.2	turn on 0.18 A charge circuit to both batteries		PWB1TN PWB2TN	T = BATT_START + BATT_DUR + 00:00:02	Turn on the 0.18A charge circuit to both batteries.
4.0	END BLOCK		STATE		Completion of BATT_MAN block execution.

5. PAYLOAD BLOCKS

The nine blocks listed in table 5-1 are used to configure the respective payload instruments throughout the mission. Subject to the constraints defined for each block, these blocks may be executed individually (e.g., for calibrations) or concurrently (e.g., transitioning to mapping or recovering from S/C anomalies).

Table 5-1 List Of Payload Blocks

No.	Block Name	Description	Mission Phase
5.1	ER	Electron Reflectometer (ER) Activation / Deactivation Block	All
5.2	ER_SA_MOD	ER Solar Array Model Configuration Block	Mapping
5.3	ER_MAP	ER Mapping Block	Mapping
5.4	MAG	Magnetometer (MAG) Activation / Deactivation Block	All
5.5	MOC	Mars Orbiter Camera (MOC) Activation / Deactivation Block	All
5.6	MOLA	Mars Orbiter Laser Altimeter (MOLA) Activation / Deactivation Block	All
5.7	MR	Mars Relay (MR) Activation / Deactivation Block	All
5.8	PDS	Payload Data Subsystem (PDS) Activation / Deactivation Block	All
5.9	TES	Thermal Emission Spectrometer (TES) Activation / Deactivation Block	All

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5.1 ER - Electron Reflectometer

5.1.1 Block Description

This block is used to activate and deactivate the Electron Reflectometer.

5.1.2 Constraints

1. The enable ER high voltage command will be issued at least two hours after the ER cover is opened. The open cover command will be issued only once, using a non-block command.

2. The MAG shall be powered on at least 20 seconds prior to ER turn on, because the MAG power commands control the power to the ER.

3. The ER shall be turned off prior to MAG power off, because the MAG power commands control the power to the ER.

Parameter Table (ER)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	ER_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the ER. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	ER_STATE	INPUT	CHAR	N/A	ON OFF	N/A	Parameter used to select the desired ER state. The two possible states are ON and OFF to power the instrument accordingly.
1.3	MAG_SIDE	INPUT	CHAR	N/A	'A' 'B'	'A'	Parameter used to select the control side of the MAG.
1.4	ER_HIVLT	INPUT	CHAR	N/A	ON OFF	OFF	Parameter used to request ER high voltage turn on.
1.5	ER_DIAG	INPUT	CHAR	N/A	ON OFF	ON	Parameter used to request instrument diagnostic turn-on.
1.6	ER_MCP	INPUT	HEX	N/A	0000-00FF	00A0	Parameter used for the setting for the MCP voltage. This value must be loaded every time the ER is turned on.
1.7	ER_PAM	INPUT	CHAR	N/A	FIXED AUTO	FIXED	Parameter used to select the ER pitch angle map automatic setting. FIXED option is used mostly in cruise phase while AUTO option is used mostly in mapping phase.
1.8	TM_RATE	INPUT	INT	bps	1296 648 324	648	Current telemetry rate. This parameter speeds up the block execution rate when possible, since the commanding must wait for a number of packets before proceeding at some places.
2.0							No PDB parameters for this block.
3.0	MAG_A	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the MAG. IF (MAG_SIDE = A) THEN MAG_A = TRUE ELSE MAG_A = FALSE

Parameter Table (ER)

No	Name	Source	Type	Units	Range	Default	Definition
3.1	MAG_B	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side B will be the control side of the MAG. IF (MAG_SIDE = B) THEN MAG_B = TRUE ELSE MAG_B = FALSE
3.2	CHKSUM	CALC	HEX	N/A	0000 - FFFF	N/A	Parameter used to designate the checksum for the ER_MCP command. CHKSUM = ER_MCP + 0x136
3.3	RATE	CALC	INT	N/A	1, 2, or 4	N/A	Parameter used to adjust block execution timing when possible, since the commanding must wait for a number of packets before proceeding at some places. RATE = 1296/TM_RATE

Event Table (ER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of ER block.
2.0	IF (ER_STATE = ON) THEN		TEST		
2.0.1	turn ER on		SCPDSC	T= ER_START	Turn the ER low voltage on.
	cmnd word set to hB101	MAG_A			
	cmnd word set to hBD01	MAG_B			
2.0.2	IF (ER_DIAG = ON) THEN				
2.0.2.1	send ER diagnostic mode 1		SCPDSC	T= ER_START +00:01:00	
	cmnd word set to hB003 opcode set to h09DC dataword 1 set to h05C8 dataword 2 set to h0201 dataword 3 set to h07C9	MAG_A			
	cmnd word set to hBC03 opcode set to h09DC dataword 1 set to h05C8 dataword 2 set to h0201 dataword 3 set to h07C9	MAG_B			

Event Table (ER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.2.2	IF (ER_HIVLT = ON) THEN				
2.0.2.2.1	enable ER high voltage		SCPDSC	T= ER_START + 00:01:00 + 150*RATE The units of 150*RATE are seconds, and may require conversion to a duration (00:00:00) format in the sequencing software.	Enable the ER high voltage. This and several later commands have variable timing based on the value of RATE, Parameter No. 3.3, which is calculated from the input parameter TM_RATE, Parameter No. 1.8. For example, if RATE=1, this command will execute at ER_START + 00:03:30; if RATE=2, execution is at 00:06:00; etc.
	cmnd word set to hB003 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0000 dataword 3 set to h012F	MAG_A			
	cmnd word set to hBC03 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0000 dataword 3 set to h012F	MAG_B			
2.0.2.2.2	set MCP to ER_MCP		SCPDSC	T= ER_START + 00:01:30 + 150*RATE	
	cmnd word set to hB003 opcode set to h0945 dataword 1 set to h0136 dataword 2 set to ER_MCP dataword 3 set to CHKSUM	MAG_A			
	cmnd word set to hBC03 opcode set to h0945 dataword 1 set to h0136 dataword 2 set to ER_MCP dataword 3 set to CHKSUM	MAG_B			
2.0.2.3	END IF				

Event Table (ER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.2.4	IF (ER_HIVLT = OFF) THEN				
2.0.2.4.1	disable ER high voltage		SCPDSC	T= ER_START + 00:01:00 + 150*RATE	Disable the ER high voltage.
	cmnd word set to hB003 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0001 dataword 3 set to h0130	MAG_A			
	cmnd word set to hBC03 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0001 dataword 3 set to h0130	MAG_B			
2.0.2.5	END IF				
2.0.2.6	send ER diagnostic mode 6		SCPDSC	T= ER_START + 00:05:00 + 150*RATE	
	cmnd word set to hB003 opcode set to h09DC dataword 1 set to h05C8 dataword 2 set to h0206 dataword 3 set to h07CE	MAG_A			
	cmnd word set to hBC03 opcode set to h09DC dataword 1 set to h05C8 dataword 2 set to h0206 dataword 3 set to h07CE	MAG_B			

Event Table (ER)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
2.0.2.7	send ER diagnostic mode 2			SCPDSC	T= ER_START + 00:05:00 + 225*RATE	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09DC				
	dataword 1 set to	h05C8				
	dataword 2 set to	h0202				
	dataword 3 set to	h07CA				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09DC				
	dataword 1 set to	h05C8				
	dataword 2 set to	h0202				
	dataword 3 set to	h07CA				
2.0.2.8	send ER diagnostic mode 4			SCPDSC	T= ER_START + 00:05:00 + 525*RATE	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09DC				
	dataword 1 set to	h05C8				
	dataword 2 set to	h0204				
	dataword 3 set to	h07CC				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09DC				
	dataword 1 set to	h05C8				
	dataword 2 set to	h0204				
	dataword 3 set to	h07CC				

Event Table (ER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.2.9	IF (ER_PAM = AUTO) THEN				
2.0.2.9.1	set ER auto PAM mode		SCPDSC	T= ER_START + 00:05:00 + 600*RATE	
	cmnd word set to hB003 opcode set to h09D3 dataword 1 set to h02AB dataword 2 set to h0000 dataword 3 set to h02AB	MAG_A			
	cmnd word set to hBC03 opcode set to h09D3 dataword 1 set to h02AB dataword 2 set to h0000 dataword 3 set to h02AB	MAG_B			
2.0.2.10	END IF				
2.0.2.11	IF (ER_PAM = FIXED) THEN				
2.0.2.11.1	set ER fixed PAM mode		SCPDSC	T= ER_START + 00:05:00 + 600*RATE	
	cmnd word set to hB003 opcode set to h09D3 dataword 1 set to h02AB dataword 2 set to h00FF dataword 3 set to h03AA	MAG_A			
	cmnd word set to hBC03 opcode set to h09D3 dataword 1 set to h02AB dataword 2 set to h00FF dataword 3 set to h03AA	MAG_B			
2.0.2.12	END IF				
2.0.3	END IF				

Event Table (ER)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
2.0.4	IF (ER_DIAG = OFF) THEN				
2.0.4.1	IF (ER_HIVLT = ON) THEN				
2.0.4.1.1	enable ER high voltage		SCPDSC	T= ER_START + 00:01:00	Enable the ER high voltage.
	cmnd word set to hB003 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0000 dataword 3 set to h012F	MAG_A			
	cmnd word set to hBC03 opcode set to h09C1 dataword 1 set to h012F dataword 2 set to h0000 dataword 3 set to h012F	MAG_B			
2.0.4.1.2	set MCP to ER_MCP		SCPDSC	T= ER_START + 00:01:30	
	cmnd word set to hB003 opcode set to h0945 dataword 1 set to h0136 dataword 2 set to ER_MCP dataword 3 set to CHKSUM	MAG_A			
	cmnd word set to hBC03 opcode set to h0945 dataword 1 set to h0136 dataword 2 set to ER_MCP dataword 3 set to CHKSUM	MAG_B			
2.0.4.2	END IF				

Event Table (ER)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
2.0.4.3	IF (ER_HIVLT = OFF) THEN					
2.0.4.3.1	disable ER high voltage			SCPDSC	T= ER_START + 00:01:00	Disable the ER high voltage.
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09C1				
	dataword 1 set to	h012F				
	dataword 2 set to	h0001				
	dataword 3 set to	h0130				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09C1				
	dataword 1 set to	h012F				
	dataword 2 set to	h0001				
	dataword 3 set to	h0130				
2.0.4.4	END IF					
2.0.5	IF (ER_PAM = AUTO) THEN					
2.0.5.1	set ER auto PAM mode			SCPDSC	T= ER_START + 00:03:00	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09D3				
	dataword 1 set to	h02AB				
	dataword 2 set to	h0000				
	dataword 3 set to	h02AB				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09D3				
	dataword 1 set to	h02AB				
	dataword 2 set to	h0000				
	dataword 3 set to	h02AB				
2.0.6	END IF					

Event Table (ER)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
2.0.7	IF (ER_PAM = FIXED) THEN					
2.0.7.1	set ER fixed PAM mode			SCPDSC	T= ER_START + 00:03:00	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09D3				
	dataword 1 set to	h02AB				
	dataword 2 set to	h00FF				
	dataword 3 set to	h03AA				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09D3				
	dataword 1 set to	h02AB				
	dataword 2 set to	h00FF				
	dataword 3 set to	h03AA				
2.0.8	END IF					
2.0.9	END IF					
2.1	END IF					
3.0	IF (ER_STATE = OFF) THEN					
3.0.1	disable ER high voltage			SCPDSC	T= ER_START	Disable ER high voltage.
	cmnd word set to	hB003	MAG_A			
	opcode set to	h0943				
	dataword 1 set to	h012F				
	dataword 2 set to	h0001				
	dataword 3 set to	h0130				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h0943				
	dataword 1 set to	h012F				
	dataword 2 set to	h0001				
	dataword 3 set to	h0130				

Event Table (ER)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
3.0.2	turn ER off			SCPDSC	T= ER_START +00:01:00	Turn ER off.
	cmnd word set to	hB102	MAG_A			
	cmnd word set to	hBD02	MAG_B			
3.1	END IF					
4.0	END BLOCK			STATE		End of ER block execution.

5.2 ER_SA_MOD - ER Solar Array Model Configuration Block

5.2.1 Block Description

This block is used to set the Electron Reflectometer solar array motion modeling parameters during mapping. It will be used as needed when the solar array motion changes due to seasonal effects.

5.2.2 Constraints

Same as ER.

Parameter Table (ER_SA_MOD)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	ER_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the ER solar array model parameter update. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.2	MAG_SIDE	INPUT	CHAR	N/A	'A' 'B'	'A'	Parameter used to select the control side of the MAG.
1.3	SA_STATE	INPUT	CHAR	N/A	'ON' 'OFF'	'OFF'	Flag to determine whether the solar array model should be on or off. The power on default is off.
1.4	ELEVATION0	INPUT	REAL	degrees	-360 to +360	N/A	Starting position for the solar array elevation gimbal, at the end of eclipse.
1.5	AZIMUTH	INPUT	REAL	degrees	-90 to +90	N/A	Starting position for the solar array azimuth gimbal, at the end of eclipse.
1.6	RW_DLY	INPUT	INT (Un-signed)	seconds	0 - 6000	0	Delay from start of eclipse to start of panel rewind.
1.7	RW_RATE	INPUT	REAL	deg/sec	-0.7 to +0.7	N/A	Solar array rewind rate.
2.0							No PDB parameters for this block.
3.0	MAG_A	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the MAG. IF (MAG_SIDE = A) THEN MAG_A = TRUE ELSE MAG_A = FALSE
3.1	MAG_B	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side B will be the control side of the MAG. IF (MAG_SIDE = B) THEN MAG_B = TRUE ELSE MAG_B = FALSE

Parameter Table (ER_SA_MOD)

No	Name	Source	Type	Units	Range	Default	Definition
3.2	TCODE	CALC	HEX	N/A	0 - hFF	N/A	Calculated solar array model parameter. TCODE = INT [(360.+ ELEVATION0)*256./360.] MODULO 256
3.3	BCODE	CALC	HEX	N/A	0 - hFF	N/A	Calculated solar array model parameter. BCODE = INT [(360.+ AZIMUTH)*256./360.] MODULO 256

3.4	RCODE	CALC	HEX	N/A	0 - hFFFF	N/A	Calculated solar array model parameter.
							
							RCODE = INT [(RW_RATE*256./360.)*65536.]
							IF (RCODE<0) THEN
							RCODE = RCODE + 65536
							END IF

3.5	ACODE	CALC	HEX	N/A	0 - hFFFF	N/A	Calculated solar array model parameter. ACODE = (BCODE*256) + TCODE
3.6	CKSUM	CALC	HEX	N/A	0 - hFFFF	N/A	Calculated solar array model checksum. CKSUM = [RW_DLY + RCODE + ACODE + h0143 + (RW_DLY + RCODE + ACODE + h0143) / 65536] MODULO 65536

Event Table (ER_SA_MOD)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK			STATE		Start execution of ER solar array model parameter update block.
2.0	IF (SA_STATE = ON) THEN					
2.0.1	send ELEVATION0, AZIMUTH, RW_DLY, RW_RATE			SCPDSC	T= ER_START	
	cmnd word set to	hB005	MAG_A			
	opcode set to	h097C				
	dataword 1 set to	h0143				
	dataword 2 set to	ACODE				
	dataword 3 set to	RCODE				
	dataword 4 set to	RW_DLY				
	dataword 5 set to	CKSUM				
	cmnd word set to	hBC05	MAG_B			
	opcode set to	h097C				
	dataword 1 set to	h0143				
	dataword 2 set to	ACODE				
	dataword 3 set to	RCODE				
	dataword 4 set to	RW_DLY				
	dataword 5 set to	CKSUM				
2.0.2	send enable			SCPDSC	T= ER_START + 00:00:01	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09FD				
	dataword 1 set to	h0142				
	dataword 2 set to	h00FF				
	dataword 3 set to	H0241				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09FD				
	dataword 1 set to	h0142				
	dataword 2 set to	h00FF				
	dataword 3 set to	h0241				
2.1	END IF					

Event Table (ER_SA_MOD)

No	Event Sequence		Box Side	Symbol / Command	Timing	Descriptions
3.0	IF (SA_STATE = OFF) THEN					
3.0.1	send disable			SCPDSC	T= ER_START	
	cmnd word set to	hB003	MAG_A			
	opcode set to	h09FD				
	dataword 1 set to	h0142				
	dataword 2 set to	h0000				
	dataword 3 set to	H0142				
	cmnd word set to	hBC03	MAG_B			
	opcode set to	h09FD				
	dataword 1 set to	h0142				
	dataword 2 set to	h0000				
	dataword 3 set to	h0142				
3.1	END IF					
4.0	END BLOCK			STATE		End of ER solar array model parameter update block.

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5.3 ER_MAP - Electron Reflectometer Mapping Configuration

5.3.1 Block Description

This block is used throughout the mapping phase to generate and update the timing of a command script containing eclipse entry and exit commands to the ER, allowing the instrument to model the motion of the solar array each orbit. The execution of this block generates a command script which is loaded into the script buffer in an area reserved for reusable mission and/or phase dependent scripts. This script is executed autonomously by the flight software using Autonomous Eclipse Management (AEM) eclipse exit detection logic. The script executes an ER eclipse exit command immediately upon initiation. After a delay time equal to the orbit period minus the eclipse duration, the ER eclipse entry command is executed.

5.3.2 Constraints

1. The MAG and ER are powered on.

2. AEM eclipse exit detection logic is enabled and the appropriate script address for the ER mapping command script is provided to the flight software.

Parameter Table (ER_MAP)

No	Name	Source	Type	Units	Range	Default	Definition
1.0	MAG_SIDE	INPUT	CHAR	N/A	MAG_A MAG_B	MAG_A	Parameter used to select the control side of the MAG.
2.0	PERIOD	PDB (OPTG)	DUR	hh:mm:ss	N/A	N/A	Orbit period for the selected orbit.
2.1	ECL_START	PDB (OPTG)	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Eclipse start time for the selected orbit.
2.2	ECL_END	PDB (OPTG)	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Eclipse exit time for the selected orbit.
3.0	ER_DUR	CALC	DUR	hh:mm:ss	N/A	N/A	Equal to the time duration between eclipse exit and eclipse entry. ER_DUR = PERIOD - (ECL_END - ECL_START)

Event Table (ER_MAP)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of ER Mapping block.
2.0	send ER eclipse exit command to MAG side A electronics cmnd word set to hB000 dataword 1 set to h0680	MAG_A	SCPDSC	T= ECL_END	Issue the ER eclipse exit command.
2.1	send ER eclipse exit command to MAG side B electronics cmnd word set to hBC00 dataword 1 set to h0680	MAG_B	SCPDSC		
3.0	send ER eclipse entry command to MAG side A electronics cmnd word set to hB000 dataword 1 set to h0601	MAG_A	SCPDSC	T= ECL_END + ER_DUR	Issue the ER eclipse entry command.
3.1	send ER eclipse entry command to MAG side B electronics cmnd word set to hBC00 dataword 1 set to h0601	MAG_B	SCPDSC		
4.0	END BLOCK		STATE		End of ER_MAP block execution.

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5.4 MAG - Magnetometer

5.4.1 Block Description

This block is used to activate and deactivate the Magnetometer.

5.4.2 Constraints

1. Both MAG side A and MAG side B shall not be powered on at the same time.

2. The PDS shall be verified to be listening to the correct MAG BIU (A or B) prior to MAG power on.

Parameter Table (MAG)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	MAG_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the MAG. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	MAG_STATE	INPUT	CHAR	N/A	ON OFF	ON	Parameter used to select the desired MAG state (i.e. on or off).
1.3	MAG_SIDE	INPUT	CHAR	N/A	A B	A	Parameter used to select the desired control side of the MAG for the power on and power off options.
2.0							No PDB parameters for this block.
3.0	MAG_A	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the MAG. IF (MAG_SIDE = A) THEN MAG_A = TRUE ELSE MAG_A = FALSE
3.1	MAG_B	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side B will be the control side of the MAG. IF (MAG_SIDE = B) THEN MAG_B = TRUE ELSE MAG_B = FALSE

Event Table (MAG)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of MAG block.
2.0	IF (MAG_STATE = 'ON') THEN		TEST	T= MAG_START	
2.0.1	turn MAG power on	MAG_A MAG_B	IMPWAN IMPWBN	T= MAG_START + 00:00:01	Turn MAG power on for the desired side.
2.0.2	turn ER heater on		IEHTRN	T= MAG_START + 00:00:02	This command does not turn the heater on but enables the heater's thermostatic control. This heater will remain enabled for the duration of the mission. Note that this command may be redundant.
2.1	END IF		TEST		
3.0	IF (MAG_STATE = 'OFF') THEN		TEST	T= MAG_START	
3.0.1	turn MAG power off	MAG_A MAG_B	IMPWAF IMPWBF		Turn MAG power off for desired side.
3.1	END IF		TEST		
4.0	END BLOCK		STATE		End of MAG block execution.

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5.5 MOC - Mars Orbiter Camera

5.5.1 Block Description

This block is used to activate and deactivate the Camera.

5.5.2 Constraints

1. The PDS must be verified to be listening to the correct MOC BIU (A, B, or A and B) prior to MOC power on.

Parameter Table (MOC)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	MOC_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the MOC. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.2	MOC_STATE	INPUT	CHAR	N/A	ON OFF	ON	Parameter used to select the desired instrument state (i.e. on or off).
1.3	HTR_STATE	INPUT	CHAR	N/A	ON OFF	ON	Parameter used to select the desired MOC survival heater state (i.e. on or off). The current mission phase is used to determine the state of the MOC replacement heater when turning the instrument on or off.
1.4	MOC_SIDE	INPUT	CHAR	N/A	A B BOTH	A	Parameter used to select the desired MOC control side for turning on or off the instrument. BOTH option is used if both sides of the MOC are to be powered on at the same time.
2.0							No PDB parameters for this block.
3.0	MOC_A	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the MOC for turning on or off the instrument. IF (MOC_SIDE = BOTH OR A) THEN MOC_A = TRUE ELSE MOC_A = FALSE
3.1	MOC_B	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the MOC for turning on or off the instrument. IF (MOC_SIDE = BOTH OR B) THEN MOC_B = TRUE ELSE MOC_B = FALSE

Event Table (MOC)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of MOC block.
2.0	IF (MOC_STATE = 'ON') THEN		TEST	T = MOC_START	
2.0.1	turn MOC survival heater off		ICHTMF		For all mission phases except inner cruise, the MOC replacement heater will be powered on whenever the instrument is powered off. Thus when turning on the instrument power, the replacement heaters will first be powered off. For inner cruise, this command may be redundant since it should already be off.
2.0.2	turn MOC power on	MOC_A MOC_B	ICPWAN ICPWBN	T = MOC_START + 00:01:00	Power on the MOC.
2.1	END IF		TEST		
3.0	IF (MOC_STATE = 'OFF') THEN		TEST	T = MOC_START	
3.0.1	turn MOC power off	MOC_A MOC_B	ICPWAF ICPWBF		Power off the MOC.
3.0.2	IF (HTR_STATE = 'ON') THEN		TEST		For all mission phases except inner cruise, the MOC replacement heater will be powered on when the instrument is powered off. However, for inner cruise the replacement heaters should not be turned on when powering off the instrument due to potential over-temperature conditions.
3.0.2.1	turn MOC survival heater on		ICHTMN	T = MOC_START + 00:01:00	
3.0.3	END IF		TEST		
3.1	END IF		TEST		
4.0	END BLOCK		STATE		End of MOC block execution.

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5.6 MOLA - Mars Orbiter Laser Altimeter

5.6.1 Block Description

This block is used to activate and deactivate the Laser Altimeter.

5.6.2 Constraints

None.

Parameter Table (MOLA)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	MOLA_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the MOLA. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	MOLA_STATE	INPUT	CHAR	N/A	ON OFF	ON	Parameter used to select the desired instrument state (i.e. on or off).
1.3	MOLA_DISABL	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Parameter used to determine if the MOLA will be disabled and disarmed after being powered off (i.e. MOLA_STATE = OFF). If set to TRUE, the MOLA will be disabled and disarmed. However, the disable and disarm commands will normally be used only in ground testing of the block. They are not planned for use in normal flight operations.
2.0							No PDB parameters for this block.
3.0							No calculated parameters for this block.

Event Table (MOLA)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of MOLA block.
2.0	IF (MOLA_STATE = 'ON') THEN		TEST	T = MOLA_START	
2.0.1	turn MOLA replacement heater off		ILHTRF		Turn off the MOLA replacement heater, before turning on the instrument power.
2.0.2	enable MOLA power		ILPWRE	T = MOLA_START + 00:00:01	This command may be redundant.
2.0.3	arm MOLA power		ILPWRA	T = MOLA_START + 00:00:02	This command may be redundant.
2.0.4	turn MOLA power on		ILPWRN	T = MOLA_START + 00:00:03	
2.1	END IF		TEST		
3.0	IF (MOLA_STATE = 'OFF') THEN		TEST	T = MOLA_START	
3.0.1	turn MOLA power off		ILPWRF		
3.0.2	IF (MOLA_DISABL) THEN		TEST	T = MOLA_START + 00:00:01	
3.0.2.1	disarm MOLA power		ILPWRD		
3.0.2.2	disable MOLA power		ILPWRX	T = MOLA_START + 00:00:02	
3.0.3	END IF		TEST		
3.0.4	turn MOLA replacement heater on		ILHTRN	T = MOLA_START + 00:00:03	Turn on the MOLA replacement heater, after turning off the instrument power.
3.1	END IF		TEST		
4.0	END BLOCK		STATE		End of MOLA block execution.

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5.7 MR - Mars Relay

5.7.1 Block Description

This block is used to activate and deactivate the Relay.

5.7.2 Constraints

1. The MR shall only be powered on if the MOC has been placed into the MR-compatible operating configuration.

Parameter Table (MR)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	MR_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the MR. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.2	MR_STATE	INPUT	CHAR	N/A	'ON' 'MODE' 'OFF'	'ON'	Parameter used to select the desired instrument configuration.
1.3	MR_DISABLE	INPUT	FLAG	N/A	TRUE FALSE	FALSE	Flag used to determine if the MR power will be disabled (i.e. MR_DISABLE set to TRUE) as part of the deactivation option in the block (i.e., MR_STATE = 'OFF'). Nominally, the disable power command will only be used in ground testing of the block. It is not planned for use in normal flight operations.
1.4	MR_MODE	INPUT	CHAR	N/A	M1 - M16	N/A	The desired operational mode for the MR. The 16 modes select various combinations of landers (L1, L2, L3, L1/L2, or L1/L3), Beacon (on/off), Rate (R1, R2), Frequency (F1, F2, F1/F2), and Viterbi coding (on/off).
2.0							No PDB parameters for this block.
3.0							No calculated parameters for this block.

Event Table (MR)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of MR block.
2.0	IF (MR_STATE = 'ON') THEN		TEST	T = MR_START	
2.0.1	set MR mode to control off word 1 set to 000F		IRMCBO		
2.0.2	enable MR power		IRPWRE	T = MR_START + 00:00:01	This enable power command may be redundant.
2.0.3	turn MR power on		IRPWRN	T = MR_START + 00:00:02	Turn the MR power on.
2 .1	END IF		TEST		
3.0	IF (MR_STATE = MODE) THEN		TEST	T = MR_START	
3.0.1	set MR to the desired mode word 1 set to MR_MODE		IRMCBO		Command the MR to the desired mode (M1 through M16). See MR ICD, figure 10 for the full command organization of the 16 MR modes.
3.1	END IF		TEST		
4.0	IF (MR_STATE = 'OFF') THEN		TEST	T = MR_START	
4.0.1	set MR mode to control off word 1 set to 000F		IRMCBO		
4.0.2	turn MR power off		IRPWRF	T = MR_START + 00:00:01	
4.0.3	IF (MR_DISABLE) THEN		TEST	T = MR_START + 00:00:02	It is desired not to execute this relay if it is not necessary.
4.0.3.1	disable MR power		IRPWRX		
4.0.4	END IF		TEST		
4.1	END IF		TEST		
5.0	END BLOCK		STATE		End of MR block execution.

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5.8 PDS - Payload Data Subsystem

5.8.1 Block Description

This block is used to activate and deactivate the Payload Data Subsystem.

5.8.2 Constraints

1. PDS side A and PDS side B shall not be powered on at the same time. Violation of this constraint could cause loss of science data, but will not harm either PDS half.

Parameter Table (PDS)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	PDS_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the PDS. This parameter will appear as the SEQGEN “Request Start Time” separately from the remaining parameters.
1.2	PDS_STATE	INPUT	CHAR	N/A	'ON' 'LOAD' 'WRITE_ON' 'READOUT' 'PDS_RAM' 'OFF'	'ON'	Parameter used to select the desired instrument state. Options 'ON' and 'OFF' will be executed as a stored command sequence. Options 'WRITE_ON', 'READOUT' and 'PDS_RAM' will be executed as a realtime command sequence. After powering on the PDS and RAM operation is desired, the 'LOAD' option must be executed first where the write protects are turned off and the PDS RAM loaded. After allowing adequate time for the RAM load, the 'READOUT' option is then executed. After verifying the readouts (redundant memory readouts may be desired), the 'PDS_RAM' option is executed which transfers the PDS from PROM to RAM and sets the PDS to low rate record mode.
1.3	PDS_SIDE	INPUT	CHAR	N/A	'A' 'B'	'A'	Parameter used to select the desired control side of the PDS for the power on and power off options.
1.4	SEG_ADDR	INPUT	HEX	N/A	0000 - FFFF	N/A	Parameter used to select the segment address in bytes for a PDS memory readout.
1.5	OFF_ADDR	INPUT	HEX	N/A	0000 - FFFF	N/A	Parameter used to select the offset address in bytes for a PDS memory readout.
1.6	WORD_NO	INPUT	HEX	N/A	0000 - FFFF	N/A	Parameter used to select the number of words to be read out for a PDS memory readout.
1.7	CHKSUM	INPUT	HEX	N/A	0000 - FFFF	N/A	Parameter used to select the checksum for a PDS memory readout.
2.0							No PDB parameters for this block.

Parameter Table (PDS)

No	Name	Source	Type	Units	Range	Default	Definition
3.0	PDS_A	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side A will be the control side of the PDS, for the power on or off option. IF (PDS_SIDE = A) THEN PDS_A = TRUE ELSE PDS_A = FALSE
3.1	PDS_B	CALC	SIDE	N/A	TRUE FALSE	N/A	Flag designating whether side B will be the control side of the PDS, for the power on or off option. IF (PDS_SIDE = B) THEN PDS_B = TRUE ELSE PDS_B = FALSE

Event Table (PDS)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of PDS block.
2.0	IF (PDS_STATE = 'ON') THEN		TEST	T = PDS_START	The PDS turn on event will be executed as a stored command sequence.
2.0.1	turn PDS power on	PDS_A PDS_B	CPPWAN CPPWBN		The command to turn the desired PDS side on will also turn the other side off.
2.0.2	enable PDS telemetry monitor		STPTME	T = PDS_START +00:01:00	This command will enable the PDS telemetry monitor. If the PDS resets 3 consecutive samples, the telecom task in the flight software will reconfigure to engineering mode. In the case of late inner cruise when the 2 kbps rate is unsupported, the COMM block will have to be used to reconfigure telecom to mission mode.
2.1	ENDIF		TEST		
3.0	IF (PDS_STATE = 'LOAD') THEN		TEST	T = PDS_START	Events 3.0 through 6.1 will be executed as a realtime command sequence.
3.0.1	set PDS to EOM mode word count set to h0001 command word set to h3980		SCPDSC		Set the PDS to engineering only mode.
3.0.2	turn off PDS write protects word 1 set to h0000	PDS_A PDS_B	CPAWP0 CPBWP0	T = PDS_START + 00:01:00	Before uploading the PDS RAM, the write protects are turned off.
3.0.3	load PDS RAM		PLOADM	T = PDS_START + 00:02:00	Load the PDS memory. The duration of the upload will be determined from the size of the upload and a 125 bps uplink rate.
3.1	ENDIF		TEST		

Event Table (PDS)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
4.0	IF (PDS_STATE = 'WRITE_ON') THEN		TEST	T = PDS_START	
4.0.1	turn on PDS write protects word 1 set to h001C	PDS_A PDS_B	CPAWP0 CPBWP0		After the completion of the realtime PDS RAM load, the PDS write protects will be turned back on.
4.1	ENDIF		TEST		
5.0	IF (PDS_STATE = 'READOUT') THEN			T = PDS_START	
5.0.1	perform PDS memory readout word count set to h0006 command word set to h3884 opcode set to h0F80 dataword 1 set to SEG_ADDR dataword 2 set to OFF_ADDR dataword 3 set to WORD_NO dataword 4 set to CHKSUM		SCPDSC		A memory readout of the PDS will be performed to verify the upload. The memory readout consists of three parts, the first of which is to readout the PDS RAM up to common data. The second part of the memory readout consists of reading out the PDS RAM , starting from common data up to the end of the stack. The final part of the memory readout consists of reading out the PDS PROM code and data. If a redundant memory readout is commanded, allow at least ten minutes for the completion of the third part of the first memory readout before starting the consecutive one.
5.1	ENDIF		TEST		
6.0	IF (PDS_STATE = 'PDS_RAM') THEN		TEST	T = PDS_START	
6.0.1	command PDS to RAM word count set to h0001 command word set to h3991		SCPDSC		Transfer PDS from PROM to RAM, after successful verification of the memory load.
6.0.2	set PDS to LRC mode word count set to h0001 command word set to h3902		SCPDSC	T = PDS_START + 00:01:00	Set the PDS to low rate record mode.
6.1	ENDIF		TEST		

Event Table (PDS)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
7.0	IF (PDS_STATE = 'OFF') THEN		TEST	T = PDS_START	The PDS turn off event will be executed as a stored command sequence.
7.0.1	disable PDS telemetry monitor		STPTMX		This command will disable the PDS telemetry monitor.
7.0.2	turn PDS power off	PDS_A PDS_B	CPPWAF CPPWBF	T = PDS_START +00:00:01	Power off the PDS.
7.1	ENDIF		TEST		
8.0	END BLOCK		STATE		End of PDS block execution.

5.9 TES - Thermal Emission Spectrometer

5.9.1 Block Description

This block is used to activate and deactivate the Thermal Emission Spectrometer.

5.9.2 Constraints

1. The PDS RAM must be loaded prior to TES power on. This precaution avoids the situation where the spacecraft could be in Safe mode (PDS in PROM-EOM) and experience an SEU which would reset the PDS to PROM-LRS, reinstating the clock and causing the TES to unsafe itself (open the cover, which is an undesirable state for power off). See Flight Rule 1302-B-TES.

Parameter Table (TES)

No	Name	Source	Type	Units	Range	Default	Definition
1.1	TES_START	INPUT	TIME	yy-ddd/ hh:mm:ss	N/A	UTC	Desired time to begin the power on/off event for the TES. This parameter will appear as the SEQGEN "Request Start Time" separately from the remaining parameters.
1.2	TES_STATE	INPUT	CHAR	N/A	'ON' 'SAFE' 'OFF'	'ON'	Parameter used to select the desired instrument state. The 'ON' and 'SAFE' states are to be performed via stored sequence commands. However, since it is necessary to verify TES safing prior to instrument turn off, the 'OFF' state is to be performed via nonstored (realtime) commands.
2.0							No PDB parameters for this block.
3.0							No calculated parameters for this block.

Event Table (TES)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
1.0	START BLOCK		STATE		Start execution of TES block.
2.0	IF (TES_STATE = 'ON') THEN		TEST		
2.0.1	turn TES replacement heater off		ITHTRF	T = TES_START	The TES replacement heater must be turned off prior to powering on the instrument.
2.0.2	turn TES power on		ITPWRN	T = TES_START + 00:00:01	Power on the TES.
2.0.3	set optical switch command word set to h9803 opcode set to h06CE dataword 1 set to h0002 dataword 2 set to h0000 dataword 3 set to h0002		SCPDSC	T= TES_START + 00:02:06	At power on, the optical switch is in an indeterminate state. This command sets it to a known state.
2.1	END IF		TEST		
3.0	IF (TES_STATE = 'SAFE') THEN		TEST		
3.0.1	flush TES Output Queue command word set to h9800 opcode set to h0651		SCPDSC	T = TES_START	
3.0.2	flush TES Output Queue command word set to h9800 opcode set to h0651		SCPDSC	T= TES_START + 00:00:10	
3.0.3	safe TES command word set to h9800 opcode set to h06C8		SCPDSC	T= TES_START + 00:00:20	
3.0.4	safe TES command word set to h9800 opcode set to h06C8		SCPDSC	T= TES_START + 00:00:50	

Event Table (TES)

No	Event Sequence	Box Side	Symbol / Command	Timing	Descriptions
3.0.5	request diagnostic packet command word set to h9800 opcode set to h0645		SCPDSC	T= TES_START + 00:01:20	
3.0.6	request diagnostic packet command word set to h9800 opcode set to h0645		SCPDSC	T= TES_START + 00:02:20	
3.1	END IF		TEST		
4.0	IF (TES_STATE = 'OFF') THEN		TEST		This is the TES power off option which will performed via nonstored (realtime) commands.
4.0.1	turn TES power off		ITPWRF	T= TES_START	
4.0.2	turn TES power off		ITPWRF	T= TES_START + 00:01:00	
4.0.3	turn TES replacement heater on		ITHTRN	T= TES_START + 00:02:00	The TES replacement heater must be turned on after powering off the instrument.
4.0.4	turn TES replacement heater on		ITHTRN	T= TES_START + 00:03:00	
4.1	END IF		TEST		
5.0	END BLOCK		STATE		End of TES block execution.

6. ACRONYM LIST

Acronym	Definition
AACS	Attitude and Articulation Control System
ABM	Aerobrake Maneuver
AEM	Autonomous Eclipse Management
ANS	Array Normal Spin
BCR	Battery Charge Regulator
BOT	Beginning of Tape
bps	Bits per second
C&DH	Command and Data Handling
CIU	Control Interface Unit
CIX	Control Interface Extender
CMD	Command
CSA	Celestial Sensor Assembly
DOR	Differential One-Way Ranging
DRD	Data Requirement Description
DSN	Deep Space Network
DTC	Dual Temperature Controller
EDF	Engineering Data Formatter
ER	Electron Reflectometer
ETF	Engineering Transfer Frame
EVP	Earth View Period
FMECA	Failure Modes, Effects and Criticality Analysis
FOV	Field of View
FSW	Flight Software
Gbit	Gigabit
GDE	Gimbal Drive Electronics
GDS	Ground Data System
H/W	Hardware
HEF	High Efficiency
HGA	High Gain Antenna
Hz	Hertz
ICD	Interface Control Document
I, INT	Integer
IMU	Inertial Measurement Unit
ISH	Inertial Slew Hold
JPL	Jet Propulsion Laboratory
kbps	Kilobits per Second
kHz	Kilohertz
ksps	Kilosymbols per Second
LGA, LGT1, LGT2	Low Gain Antenna, LGA #1, LGA #2
LV	Latch Valve

Acronym	Definition
m/s	Meters per Second
MAG	Magnetometer
MGS	Mars Global Surveyor
MHSA	Mars Horizon Sensor Assembly
MO	Mars Observer
MOC	Mars Orbiter Camera
MOI	Mars Orbit Insertion
MOLA	Mars Orbiter Laser Altimeter
MOS	Mission Operations System
MOT	Mars Orbital Transponder
MR	Mars Relay
mV	Millivolt
NASA	National Aeronautics and Space Administration
NAV	Navigation
NSI	NASA Standard Initiator
OPTG	Orbit Propagation and Timing Geometry
OTM	Orbit Trim Maneuver
PB	Playback
PDB	Project Data Base
PDS	Payload Data Subsystem
PID	Proportional Integral Derivative
PMS	Power Management Software
PRA	Pyro Relay Assembly
pri	Primary
psi(a)	Pounds per square inch (absolute)
PV	Pyro Valve
rad	Radian
RAM	Read Only Memory
RCS	Reaction Control System
REA	Rocket Engine Assembly
REC	Record, Recorder
REDMAN	Redundancy Management
RF	Radio Frequency
RS	Radio Science
RSE	Radio Science Egress
RSI	Radio Science Ingress
RPA	RF Power Amplifier (TWTA)
RT	Realtime
RWA	Reaction Wheel Assembly

<u>Acronym</u>	<u>Definition</u>
S&E-1	Science & Engineering Data Stream 1
S&E-2	Science & Engineering Data Stream 2
S/C	Spacecraft
S/W	Software
SA	Solar Array
SCP	Standard Control Processor
sec	Secondary, Second
SEQ	Sequence Generation Subsystem Software
SEQGEN	Sequence Generation Software
SEU	Single Event Upset
SPF	Single Point Failure
SSA	Sun Sensor Assembly
SSI	Sun / Star / Init
SSR	Solid State Recorder (consisting of 2 “recorders”)
TBD	To be Determined
TBS	To be Supplied
TCM	Trajectory Correction Maneuver
TES	Thermal Emission Spectrometer
TLM	Telemetry
TWNC	Two-Way Non-Coherent
TWTA	Traveling Wave Tube Amplifier
USO	Ultra Stable Oscillator
UTC	Universal Time Coordinated
wcount, wcnt	Wheel counts (1 wcount = 5 rpm)
XSU	Cross-Strap Unit